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26 JUNE 1986

# USSR REPORT

## PHYSICS AND MATHEMATICS

### CONTENTS

#### ACOUSTICS

Light Pressure and Sound (F.Kh. Gelmukhanov; AKUSTICHESKIY ZHURNAL, No 4, Jul-Aug).....	1
Radiation Patterns of Thermo-optical Source of Acoustic Waves Excitable in Metals by Narrow Laser Beam (S.I. Zolotov, V.V. Krylov, et al.; AKUSTICHESKIY ZHURNAL, No 4, Jul-Aug 85).....	1
Radiation of Sound by Turbulence Near a Wall (L.M. Lyamshev, A.T. Skvortsov; PISMA V ZHURNAL TEKHNICHESKOY FIZIKI, No 11, 12 Jul 85).....	2
Scattering of Acoustic Waves by a Circular Liquid Cylinder Containing a Liquid Filler (N. Veksler, Yu. Kartashov; IZVESTIYA AKADEMII NAUK ESTONSKOY SSR: FIZIKA MATEMATIKA, No 2, Apr-Jun 85).....	3
Photoacoustic Method of Determining Thermophysical Characteristics, Part 2 (S.A. Vinokurov; INZHENERNO-FIZICHESKIY ZHURNAL, No 1, Jan 85).....	3

#### CRYSTALS, LASER GLASSES AND SEMICONDUCTORS

Focusing of an Elastic Impulse in Solid Bodies With Dislocation Accumulations (V.V. Klubovich, S.A. Kirillov, et al.; VESTSI AKADEMII NAVUK BSSR: SERIYA FIZIKA- MATEMATYCHNYKH NAVUK, No 6, Nov-Dec 85).....	5
---	---

Calculation of Mechanical Stresses in 'Semiconductor Laser-Heat Sink' System (L.N. Kuzmin, G.I. Ryabtsev; VESTSI AKADEMII NAVUK BSSR: SERIYA FIZIKA-MATEMATYCHNYKH NAVUK, No 4, Jul-Aug 85).....	5
Calculation of High Energy Positron and Electron Radiation Spectra With Flat Channeling in Diamond-Type Crystals (A.R. Avakyan, Yanshi; IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA, No 4, Jul-Aug 85).....	7
Modulation of Optical Radiation in Crystals by Coherent Ultrasonic Excitation (L.A. Kocharyan, E.M. Arutyunyan, et al.; IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA, No 4, Jul-Aug 85).....	7
Study of CdS Surface by Optical Methods Upon Adsorption of Organic Dyes (O.M. Getsko, O.V. Snitko, et al.; FIZIKA, KHIMIYA MEKHANIKA, No 7, Jul 85).....	8
Interaction Section of Ultrasonic Wave and Structural Dislocations in Solid (N.T. Kvasov; VESTSI AKADEMII NAVUK BSSR, No 2, Mar-Apr 85).....	8
Complex Center of Scintillating Luminescence in Electron- Bombarded CdS Single Crystals (N.S. Bogdanyuk, A.P. Galushka, et al.; FIZIKA TVERDOGO TELA, No 7, Jul 85).....	9
Study of $4f^25d$ Configuration of $Nd^{3+}$ Ion in Crystals by Method of Absorption From Excited State (M.A. Dubinskiy, A.L. Smolov; FIZIKA TVERDOGO TELA, No 7, Jul 85).....	10
Role of Surface Space Charge in Formation of Surface Exciton in Semiconductors (O.S. Zinets; FIZIKA TVERDOGO TELA, No 7, Jul 85).....	10
Energy Transfer in Solid Bodies; New Active Media for Solid State Lasers (I.A. Shcherbakov; USPEKHI FIZICHESKIKH NAUK, No 2, Jun 85).....	11
Tests of Several Neodymium Glasses for Comparison of Their Lasing Characteristics (G.D. Berzina, M.A. Borik, et al.; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	11

## GAS DYNAMICS

- Investigation of Structures of High Frequency  
Nonindependent Discharge in Gas Stream  
(A.S. Kovalev, Ye.A. Muratov, et al.;  
FIZIKA PLAZMY, No 7, Jul 85)..... 13
- Erosion of Pulse Front of Relativistic Electron  
Beam in Neutral Gas  
(G.P. Mkheidze, A.A. Savin, et al.;  
ZHURNAL TEKHNIЧЕСКОY FIZIKI No 7, Jul 85)..... 13
- Gas Kinetics in Laser Radiation Field  
(F.Kh. Gelmukhanov; AVTOMETRIYA, No 1,  
Jan-Feb 85)..... 14
- Enlargement of Aerosol Particles Through Condensation  
During Mixing of Gas and Vapor  
(Ye.V. Sugak, V.P. Isakov; INZHENERNO-  
FIZICHESKIY ZHURNAL, No 1, Jan 85)..... 14
- Rotational Relaxation in Gases: Survey  
(A.I. Osipov; INZHENERNO-FIZICHESKIY ZHURNAL,  
No 1, Jan 85)..... 15

## FLUID DYNAMICS

- Relativistic Theory of Superfluidity: Phenomenological  
Approach  
(P.I. Fomin, V.N. Shadura; DOKLADY AKADEMII NAUK  
UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE  
I TEKHNIЧЕСКИYE NAUKI, No 6, Jun 85)..... 16

## HIGH-TEMPERATURE PHYSICS

- Reflection of Pulsed Radiation From Ruby Laser by  
Copper Target in Air or in Vacuum  
(A.Ya. Vorobyev; KVANTOVAYA ELEKTRONIKA,  
No 4, Apr 85)..... 17
- Characteristics of Coherent Radiation Reflected by  
Rough Surface  
(N.D. Ustinov, A.V. Anufriyev, et al.;  
KVANTOVAYA ELEKTRONIKA, No 4, Apr 85)..... 18
- Experimental Study of Luminescence of Hot  
Electrons in Metals  
(M.B. Agranat, S.I. Ashitkov; IZVESTIYA AKADEMII  
NAUK SSSR: SERIYA FIZICHESKAYA, No 7, Jul 85)..... 19

Formation of Periodic Microrelief on the Surface of Transparent Bodies Under the Influence of Laser Radiation (G.A. Golubenko, V.L. Maslennikov, et al.; POVERKHNOST: FIZIKA, KHIMIYA, MEKHANIKA, No 7, Jul 85).....	20
Effect of High-Power Laser Radiation on Surfaces of Semiconductors and Metals: Nonlinear Optical Effects and Nonlinear Optical Diagnosis (S.A. Akhmanov, V.I. Yemelyanov, et al.; USPEKHI FIZICHESKIKH NAUK, No 4, Dec 85).....	20
Dynamics of Phase Transformation in Semiconductors Under Laser Irradiation (S.A. Oseredko; INZHENERNO-FIZICHESKIY ZHURNAL, No 1, Jan 85).....	21
LASERS	
Numerical Analysis of Mixing Effects in Chemical Oxygen-Iodine Laser (V.N. Azyazov, V.I. Igoshin, et al.; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEVEDEVA, No 115, 1984).....	22
Chemical Lasers on Photon-Branching Chain Reactions (N.G. Basov, V.I. Igoshin, et al.; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA, No 121, 1984).....	23
Numerical Multiparametric Optimization of $D_2-F_2-CO_2$ Chemical Pulse Laser (E.U. Baykov, A.S. Bashkin, et al.; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA, No 167, 1984).....	23
Effective Passive Shutter for Neodymium-Glass Laser With Mode Self-Locking (V.A. Babenko, V.I. Malyshev, et al.; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEVEDEVA, No 171, 1984).....	24
Small-Signal Gain and Saturation Factor of Waveguide Laser With Distributed Losses (P.Ye. Dubovskiy, E.N. Lotkova, et al.; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA, No 206, 1984).....	25

The Laser Strength of Active Elements Made of Gadolinium-Scandium-Gallium Garnet (GSGG) (Yu.K. Kanileyko, Ye.V. Zharikov, et al.; KVANTOVAYA ELEKTRONIKA, No 2, Feb 85).....	27
Energetic Processes in Solid-State Lasers: Free Emission Mode (Numerical Simulation) (V.M. Gradov, B.A. Kostantinov, et al.; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA, No 56, 1984).....	30
Gas-Dynamic Lasers on Cascade Transition in CO <sub>2</sub> , N <sub>2</sub> O, CS <sub>2</sub> Molecules Mixing With Active Component (A.S. Biryukov, I.V. Karakhanova, et al.; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA, No 87, 1984).....	31
'Luminous Boiler' and Problem of Raising Efficiency of Solid-State Lasers With Phototube Pumping (N.G. Basov, V.A. Gerasimov, et al.; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA, No 106, 1984).....	32
Effect of Strain Anisotropy on Emission Characteristics of GaInPAs/InP Lasers (P.G. Yeliseyev, V.N. Sverdlov, et al.; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA, No 107, 1984).....	33
Efficient Quasi-Continuous High-Pressure Nitrogen Laser on First Negative System (N.G. Basov, A.Yu. Aleksandrov, et al.; PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, No 1, 10 Jul 85).....	34
Energy Study of a Picosecond Dye Laser With Distributed Feedback (A.Sh. Ambaryan, A.Zh. Muradyan, et al.; IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA, No 4, Jul-Aug 85).....	35
A 2.12 Micrometer No:YAG Laser (B.M. Antipenko, A.S. Glebov, et al.; PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI No 11, 12 Jul 85).....	35
Ionization Diagnosis of Density of Molecular Beams Based on Laser-Induced Electron Transfer (I.M. Beterov, N.V. Fateyev, et al.; PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI No 11, 12 Jul 85).....	36

Effective Modes for Generating and Amplifying Ultrashort Light Pulses in Ruby and YAG:Nd Crystals (Oleg Petrovich Varnavskiy, EFFEKTIVNYYE REZHIMY GENERATSII I USILENIYA ULTRAKOROTKIKH IMPULSOV SVETA V RUBINE I AIG:Nd, 1984).....	36
Investigation of Influence of Anion in Polymethine Dye Molecule on Output Characteristics of Passive Mode- Locked Laser (M.I. Demchuk, V.P. Mikhaylov, et al.; DOKLADY AKADEMII NAUK BSSR, No 5, 1985).....	37
Gain Contour Spectrum of Injection Lasers on AlGaAs Diheterostructure With Weakly Doped Active Region (Yu.L. Bessonov, V.N. Morozov, et al.; KRATKIYE SOOBSHCHENIYA PO FIZIKE: SBORNIK, No 3, Mar 85).....	37
Effect of Threshold Conditions on Spectral and Noise Characteristics of Injection Lasers With Narrow Strip Contact (Yu.L. Bessonov, A.A. Borodkin, et al.; KRATKIYE SOOBSHCHENIYA PO FIZIKE: SBORNIK No 3, Mar 85).....	38
Tunable LiF Color Center Lasers (Sergey Borisovich Mirov; PERESTRAIVAYEMYYE LAZERY NA TSENTRAKH OKRASKI V KRISTALLAKH LiF, 1983).....	38
Degradation of GaAs/(Al,Ga)As Heterostructure Lasers Mounted on Heat Sink Through Hard Solder (T.B. Zhizdyuk, N.D. Zhukov, et al.; ZHURNAL TEKHNICHESKOY FIZIKI, No 7, Jul 85).....	39
Gas Dynamic Lasers Utilizing Gasification of Carbon (A.S. Biryukov, V.M. Marchenko, et al.; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	40
Febrile Response of Electrons in Semiconductor Laser to Ultrashort Light Pulse (L.A. Rivlin; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	40
Self-Focusing of Laser Radiation in Molecular Gases (A.I. Osipov, V.Ya. Panchenko, et al.; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	41
Radiation Emission by Perylene Vapor Pumped by Laser Over Broad Range of Spectrum (L.A. Barkova, V.V. Gruzinskiy, et al.; KVANTOVAYA ELEKTRONIKA No 4, Apr 85).....	42



Energy Characteristics of Autonomous Continuous-Wave Chemical CO-Laser (A.A. Stepanov, V.A. Shcheglov, et al.; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	42
Spectral Characteristics of Radiation From Continuous- Wave Dye Laser With Gaseous Absorbing Intracavit Medium (M.V. Danilevko, A.M. Negriyko, et al.; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	43
Scanned and Continuous-Wave GaSb Lasers With Longitudinal Electron-Beam Pumping (A.G. Braginskaya, V.I. Kozlovskiy, et al.; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	44
Emission Threshold and Beam Divergence of Semiconductor Lasers With Longitudinal Electron-Beam Pumping (I.L. Bogdankevich, O.V. Bogdankevich, et al.; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	45
Reflexive Effects of Radiation in Resonator of CO <sub>2</sub> -Laser (M.G. Galushkin, L.V. Kovalchuk, et al.; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	46
Increasing Efficiency of Beam-Pumped Xe-Laser by Means of Molecular Additives (F.V. Bunkin, V.I. Derzhiyev, et al.; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	46
Measurement of Gain in Ultraviolet N <sub>2</sub> -Laser (V.F. Papakin, A.Yu. Sonin; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	47

## NUCLEAR PHYSICS

Energy Estimates for Compound Heating of Thermonuclear Targets (Yu.V. Afanasyev, V.A. Isakov; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA No 114, 1984).....	49
Neutrino Beams in Multi-TeV Accelerators (V.A. Saleyev, V.A. Tsarev, et al.; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA, No 145, 1984).....	50
Possibility of Decreasing Limitations of Reactivity When Working With Gaseous Neutron Absorbers (F.M. Arinkin, G.A. Batyrbekov, et al.; IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR: SERIYA FIZIKO-MATEMATICHESKAYA, No 6, Nov-Dec 85).....	50

Measurements of Neutron Flux Allowing Determination of Certain Reactor Characteristics (A.I. Prilepko, A.L. Ivankov, et al.; INZHENERNO-FIZICHESKIY ZHURNAL, No 6, Dec 85).....	51
Analysis of Results of Gamma-Spectrometric Control of Radioactive Corrosion Products in Nitrene Coolant During Washing of Reactor Loop (V.B. Nesterenko, M.L. Zhemzhurov, et al.; VESTSI AKADEMII NAVUK BSSR: SERYYA FIZIKA- ENERGETYCHNYKH NAVUK, No 4, Oct-Dec 85).....	51
Mathematical Model for Calculation of Strength and Temperature Characteristics of a Spherical Fuel Element in a Fast Neutron Reactor (V.B. Nesterenko, Li Man Kho; VESTSI AKADEMII NAVUK BSSR: SERYYA FIZIKA- ENERGETYCHNYKH NAVUK, No 4, Oct-Dec 85).....	52
Experimental Investigation of Heating and Compression of High-Aspect Thermonuclear Targets on Delfin-1 Installation (Mikhail Petrovich Kalashnikov; EKSPERIMENTALNYYE ISSLEDOVANIYA NAGREVA I SZHATIYA VYSOKOASPEKTNYYKH TERMOYADERNYKH MISHENEY NA USTANOVKE "DEFLIN-1" 1983).....	53
Correlational Coulomb Energy of Mirror Nuclei and Their Mass Difference (V.R. Shaginyan, IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR, No 4 (125), Jul-Aug 85).....	53
Nonlinear Phenomena During Transport of High-Power Beam of Small Ion to Target (A.S. Kingsen, Yu.V. Mokhov, et al.; FIZIKA PLAZMY, No 7, Jul 85).....	54
Simple Model of Heating and Compression of Spherical Shell Targets by Intense Laser Radiation (A.A. Andreyev, N.A. Solovyev; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	54
Thermal Stability of Cryogenic Targets Under Conditions of Laser Experiment (Ye.R. Koresheva, A.I. Nikitenko; KRATKIYE SOOBSHCHENIYA PO FIZIKE: SBORNIK, No 3, Mar 85).....	55
A Method for Calculating the Braking Section of Nuclear Particles by Matter (V.F. Volkov, S.A. Gerasimov; ATOMNAYA ENERGIYA, No 4, Apr 85).....	56

Photofission Yield of  $^{242}\text{Pu}$   
 (Vo Dak Bang, Yu.S. Zamyatinin, et al.;  
 ATOMNAYA ENERGIYA, No 4, Apr 85)..... 57

Laser Source of Polarized Protons and Hydrogen Ions  
 (A.N. Zelenskiy, S.A. Kokhanovskiy, et al.;  
 PISMA V ZHURNAL EKSPERIMENTALNOY I  
 TEORETICHESKOY FIZIKI, No 1, 10 Jul 85)..... 57

## OPTICS AND SPECTROSCOPY

Dependence of Spectrum of Nitrogen-Like Ions on  
 Electron Concentration in Laser Plasma  
 (M.Yu. Bunyakova, D.S. Viktorov, et al.;  
 AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI  
 P.N. LEBEDEVA, No 204, 1984)..... 59

Refraction in Plasma and Laser Resonators for Vacuum  
 Ultraviolet Region of Spectrum  
 (V.A. Chirkov; AKADEMIYA NAUK SSSR, FIZICHESKIY  
 INSTITUT IMENI P.N. LEBEDEVA, No 102, 1984)..... 59

Use of Holographic Reflecting Diffraction Gratings for  
 Diagnosis of Laser Plasma During Spherical Heating of  
 Thermonuclear Targets  
 (N.G. Basov, I.V. Aleksandrova, et al.;  
 AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI  
 P.N. LEBEDEVA, No 90, 1984)..... 60

Semitransparent Multilayer Mirrors for X-Radiation  
 (A.V. Vinogradov, I.V. Kozhevnikov; AKADEMIYA  
 NAUK SSSR, FIZICHESKIY INSTITUT IMENI  
 P.N. LEBEDEVA, No 68, 1984)..... 61

Polarization of Radiation Scattered by a Spherical  
 Volume of a Dispersed Medium  
 (A.P. Ivanov, A.B. Gavrilovich, et al.;  
 VESTSI AKADEMII NAVUK BSSR: SERIYA FIZIKA-  
 MATEMATYCHNYKH NAVUK, No 6, Nov-Dec 85)..... 62

Collimation of Charged-Particle Beam in Spherical and  
 Cylindrical Electrostatic Mirrors  
 (V.V. Zashkvara, L.S. Yurchak, et al.;  
 IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR,  
 No 4 (125), Jul-Aug 85)..... 62

Transit Time for Charged Particles in Electronic Mirrors With Direct Optical Coupling (T.D. Daumenov, A.A. Sapargaliyev; IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR No 4 (125), Jul-Aug 85).....	63
Holographic Subtraction of Images on Basis of Recording and Space Filtration in Fourier Plane (I.S. Klimenko, S.N. Malov; ZHURNAL TEKHNICHESKOY FIZIKI, No 7, Jul 85).....	64
Feasibility of Using Gradient Lenses in Miniature Optical Data Processing Devices (Yu.V. Gurov, V.G. Ilin, et al.; ZHURNAL TEKHNICHESKOY FIZIKI, No 7, Jul 85).....	65
Resonant Transformation of Light by Relativistic Ion Beams (N.G. Basov, A.N. Orayevskiy, et al.; ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI, No 1 (7), Jul 85).....	65
Study of Quality of Three-Dimensional Approximation of a Wave Front With Zonal-Modal Correction (N.A. Dimov, A.A. Korniyenko, et al.; OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST, No 6, Jun 85).....	66
Refraction by Wind Along Homogeneous Path in Paraxial Approximation (V.V. Kolosov; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	67
Attainable Characteristics of Phase-Conjugate Adaptive System (A.B. Aleksandrov, Yu.G. Dolotin; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	67
Theory of Cascaded Third-Harmonic Generation in Approximation of Strongly Interacting Waves (E.A. Ibragimov, K.R. Samigulin, et al.; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	68
Light Scattering by Microrelief of Mirror Surface (V.M. Chekmarev; OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST, No 2, Feb 85).....	69
Properties of Optical Mirror Loop (F.G. Drik; OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST, No 2, Feb 85).....	70

Components of Integrated Optics and Main Development Trends (Review) (G.S. Svechnikov; OPTOELEKTRONIKA I POLUPROVODNIKOVAYA TEKHNIKA, No 6, 1984).....	70
Measurement of Time Characteristics of Optical Elements With Femtosecond Resolution (Yu.V. Vvedenskiy, A.B. Zuyev, et al.; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA, No 6, Jun 85).....	71
Application of Binary Correlation for Image Recognition (N.A. Khilo; DOKLADY AKADEMII NAUK BSSR No 5, 1985).....	72
Change in Polarization Structure of Oblique Beams on Natural Light by Lens System (P.I. Lamekin, K.G. Predko; VESTSI AKADEMII NAVUK BSSR, No 2, Mar-Apr 85).....	72
Statistical Structure of Photodetector Count During Recording of Multibeam Interference of Noncoherent Radiation With Lorentzian Spectral Line Contour (N.V. Laskin, A.S. Mazmanishvili; DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNIICHESKIYE NAUKI, No 6, Jun 85).....	73
Estimates of Correlation and Spectral Functions of Homogeneous and Isotropic Gaussian Random Field (A.A. Dykhovichyy; TEORIYA VEROYATNOSTEY I MATEMATICHESKAYA STATISTIKA, No 32, 1985).....	73
Organic Photochromic Material for Recording Waveguide Holograms (Yu.A. Bykovskiy, V.A. Barachevskiy, et al.; KVANTOVAYA ELEKTRONIKA, No 6, Jun 84).....	74
Scientific Soviet of the Academy of Sciences of the USSR on the Problem of 'Coherent and Nonlinear Optics' (KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	79

## PLASMA PHYSICS

Computer Simulation of Processes in Solid-State Laser Oscillators and Amplifiers With Phototube Pumping: Electric-Discharge Pumping Sources. Basic Physical Properties of Plasma in Pumping Sources (N.G. Basov, V.M. Gradov, et al.; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA, No 95, 1984).....	82
--	----

Space-Time Structure of Radiation Attending Interaction of Laser-Plasma Jet and Solid Surface (P.Ya. Pirogovskiy, A.P. Shevelko; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA, No 82, 1984).....	83
Absorption of Radiation by Turbulent Laser Plasma (V.P. Silin; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA, No 119, 1984).....	83
Study of Laser-Plasma System in 'Delfin-1' Facility (I.V. Aleksandrov, A.P. Allin, et al.; AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA, No 207, 1984).....	84
'Intershock' Studies Plasma (ZARYA VOSTOKA, 30 Oct 85).....	86
Specifics of Quasi-Linear Diffusion in Relativistic Magnetically Active Plasma (L.S. Kuzmenkov, M.I. Sitnov; VESTNIK MOSKOVSKOGO UNIVERSITETA. SERIYA 3 FIZIKA. ASTRONOMIYA, No 6, Nov-Dec 85).....	88
Probe Studies of Shock Waves in a Transverse Glow Discharge Plasma (I.V. Basargin, G.I. Mishin; PISMA V ZHURNAL TEKHNICHESKOY FIZIKI, No 21, 12 Nov 85).....	88
HF Discharge Plasma Glow at Reduced Pressure (N.A. Lashuk, Ye.T. Promasevich, et al.; ZHURNAL PRIKLADNOY MEKANIKI I TEKHNICHESKOY FIZIKI, No 5, Sep-Oct 85).....	89
Influence of Laser Radiation Wavelength of Energy Yield of Soft X-Rays From Laser Plasma (O.B. Ananin, Yu.A. Bykovskiy, PISMA V ZHURNAL TEKHNICHESKOY FIZIKI, No 11, 12 Jul 85).....	89
Diffusion Discontinuities in Inhomogeneous Plasma With Current (A.P. Dmitriev, V.A. Rozhanskij, et al.; USPEKHI FIZICHESKIKH NAUK, No 2, Jun 85).....	90
Nonlinear Ultralow Frequency Hybrid Waves in a Plasma (V.M. Chmyrev; IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: RADIOFIZIKA, No 6, Jun 85).....	90
Space-Time Modulation of Ultrarelativistic High-Current Electron Beam in Magnetized Plasma Waveguide (M.V. Kuzelev, A.A. Rukhadze, et al.; FIZIKA PLAZMY, No 7, Jul 85).....	91

Two-Potential Eddies in Magnetized Plasma (A.B. Mikhaylovskiy, V.P. Lakhin, et al.; FIZIKA PLAZMY, No 7, Jul 85).....	91
---	----

Stability of Plasma Structures in Field of Unsteady Laser Pulse With Finite Laser Beam Divergence (A.F. Nastoyashchiy; FIZIKA PLAZMY, No 7, Jul 85).....	92
---	----

Reflection of High-Intensity Relativistic Electron Beams by Synthesized Plasma Layers (R.A. Akopov, O.G. Antablyan, et al.; ZHURNAL TEKHNIЧЕСКОY FIZIKI, No 7, Jul 85).....	92
--	----

#### SUPERCONDUCTIVITY

Superconductors With Heavy Fermions (N.Ye. Alekseevskiy, D.I. Khomskiy; USPEKHI FIZICHESKIKH NAUK, No 4, Dec 85).....	94
---	----

#### TECHNICAL PHYSICS

Mechanisms of Redistribution of Alkaline Additive in MHD Generator Channel (D.I. Lamden, M.B. Reznikov; ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNIЧЕСКОY FIZIKI, No 5, Sep-Oct 85).....	95
--	----

Atmospheric-Pressure and Low-Pressure N <sub>2</sub> -Laser Amplifiers (I. Shanta, L. Kozma, et al.; KVANTOVAYA ELEKTRONIKA, No 4, Apr 85).....	95
--	----

#### THERMODYNAMICS

Soliton Mechanism of Fracture of Solids by Thermal Fluctuations (V.A. Lagunov; FIZIKA TVERDOGO TELA, No 7, Jul 85).....	97
--	----

Ignition and Combustion of Disperse Mixtures (A.V. Davydenko, V.M. Kudinov, et al.; DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNIЧЕСКИYE NAUKI, No 5, May 85).....	98
---	----

#### THEORETICAL PHYSICS

Microwave Beam Instability in Proton Synchrotrons (V.I. Balbekov, S.V. Ivanov; ATOMNAYA ENERGIYA No 1, Jul 85).....	99
---	----

## LOGIC AND GAME THEORY

- The Role of Information in a Pursuit Problem  
(A.A. Chikrin, M.V. Pittsyk; DOKLADY  
AKADEMII NAUK UKRAINSKOY SSR SERIYA A.  
FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE  
NAUKI, No 11, Nov 85)..... 100
- Differential Pursuit Games With Integral Limitations  
(Ye.M. Mukhsinov; DOKLADY AKADEMII NAUK  
TADZHIKSKOY, No 8, Aug 85)..... 100

## NUMERICAL ANALYSIS AND ALGORITHMS

- Sets of Programs for Numerical Solution of Quantum  
Problem of Scattering in Three-Particle System  
(S.A. Pozdneyev; AKADEMIYA NAUK SSSR, FIZICHESKIY  
INSTITUT IMENI P.N. LEBEDEVA, No 2, 1984)..... 101
- New Photonuclear Data Processing Algorithms  
(V.N. Bodyshev, D.V. Yudin; VESTNIK MOSKOVSKOGO  
UNIVERSITETA. SERIYA 3 FIZIKA. ASTRONOMIYA, No 6,  
Nov-Dec 85)..... 102
- A New Approach to Constructing Numerical Algorithms for  
Solving Cauchy Problems for Higher-Order Differential  
Equations  
(V.M. Vorontsov; DOKLADY AKADEMII NAUK BSSR,  
No 5, 1985)..... 102
- Solvability of Observation Problem with Sensitivity  
Algorithm  
(B.I. Konosevich; MATEMATICHESKAYA FIZIKA I  
NELINEYNAYA MEKHANIKA, No 3 (37), 1985)..... 102
- Simulation of Interaction Between High-Current  
Relativistic Electron Beam and Matter  
(V.V. Gorev, S.F. Grigoryev, et al.;  
FIZIKA PLAZMY, No 7, Jul 85)..... 103
- Convergence of Functionals With Respect to Supercritical  
Markov Processes With Branching  
(M.Yu. Belyayev; DOKLADY AKADEMII NAUK SSSR,  
No 4, Aug 85)..... 104
- Method for Randomizing Integral Operator To Solve  
Equations of Second Kind  
(Yu.V. Bulavskiy; DOKLADY AKADEMII NAUK SSSR,  
No 4, Aug 85)..... 104



Solution of Boltzmann Equation for Discrete  
Velocities

(V.V. Aristov; DOKLADY AKADEMII NAUK SSSR,  
No 4, Aug 85)..... 105

Projection Algorithms for Identification of Linear  
Objects

(L.A. Ishchenko, B.D. Liberol, et al.;  
DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A:  
FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI,  
No 7, Jul 85)..... 106

CONTROL THEORY

Problems of Optimal Measurement of a Gaussian Signal

(P.V. Golubtsov, Yu.P. Pytev, et al.;  
VESTNIK MOSKOVSKOGO UNIVERSITETA. SERIYA 3  
FIZIKA. ASTRONOMIYA, No 6, Nov-Dec 85)..... 107

Radiation of Magnetic Waves From Two and Three Flat  
Waveguides

(S.M. Zhurav; IZVESTIYA VYSSHIKH UCHEBNIKH  
ZAVEDENIY: RADIOFIZIKA, No 6, Jun 85)..... 107

OPERATIONS RESEARCH

Optimization of Moments of Systems Monitoring and  
Replacement

(A.N. Nakonechnyy; DOKLADY AKADEMII NAUK UKRAINSKOY  
SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I  
TEKHNICHESKIYE NAUKI, No 7, Jul 85)..... 108

Multistep System for Generalized Mathematical

Programming and Selection Function

(D.B. Yudin, L.A. Sholomov; DOKLADY AKADEMII  
NAUK SSSR, No 5, Jun 85)..... 108

Modeling Certain Classes of Gaussian Random Processes

(I.N. Zelepugina; DOKLADY AKADEMII NAUK UKRAINSKOY  
SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I  
TEKHNICHESKIYE NAUKI, No 6, Jun 85)..... 109

DIFFERENTIAL EQUATIONS

Random Vibrations in Certain Nonlinear Viscoelastic  
Systems

(Yu.A. Mitropolskiy, Nguyen Don An; UKRAINSKIY  
MATEMATICHESKIY ZHURNAL, No 4, Jul-Aug 85)..... 110

Weakly Regular Linear Systems of Differential Equations

(V.L. Kulik; UKRAINSKIY MATEMATICHESKIY ZHURNAL,  
No 4, Jul-Aug 85)..... 110

## ACOUSTICS

UDC 534.142:535.34

### LIGHT PRESSURE AND SOUND

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 31, No 4, Jul-Aug 85 (manuscript received 10 Apr 84) pp 522-524

GELMUKHANOV, F.Kh., Institute of Automation and Electrometry, Siberian Department, USSR Academy of Sciences

[Abstract] Acoustic vibrations of a gas in the field of a traveling light wave are considered, and the light pressure is found to add a second branch with a dispersion law  $\omega = \omega_0 \sin \theta$  to the otherwise sole branch with a dispersion law  $\omega = kc$  ( $c$  - speed of sound,  $\theta$  - angle between sound and light wave vectors). The analysis leading to this conclusion is based on the equations for the density matrix and on a change from the equations of kinetics to the equations of hydrodynamics. With known relations for the density of light pressure force and the rate of change of energy density, but with heat conduction in the gas disregarded because of its weak attenuating effect, the system of equations in small pressure and density variations is solved for the extreme case of  $kc \gg \omega_0$  and the resulting dispersion equation is tested for bifurcation. The author thanks A.M. Shalagin and M.I. Stockmann for valuable comments. References: 5 Russian. [559-2415]

UDC 534.232

### RADIATION PATTERNS OF THERMOOPTICAL SOURCE OF ACOUSTIC WAVES EXCITABLE IN METALS BY NARROW LASER BEAM

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 31, No 4, Jul-Aug 85 (manuscript received 25 Dec 84) pp 569-571

ZOLOTOV, S.I., KRYLOV, V.V., PONOMAREV, Ye.P. and SHTENTSEL, T.V., Physics Department, Moscow State University imeni M.V. Lomonosov

[Abstract] The radiation pattern of a thermo-optical sound radiator excitable by a thin-line laser beam in an aluminum specimen was measured for correlation with theory and for interpretation consistent with the concepts of symmetry. A beam with circular cross-section diameter 1 mm from a YAG:Nd<sup>3+</sup> laser

(1.06  $\mu\text{m}$  wavelength) emitting pulses of up to 8 kW power and of approximately 100 ns duration at repetition rates of 10-50 Hz was transformed by a set of lenses into a line-thin one and focused as such on a 3 mm thick flat aluminum semidisk with a 9 mm radius so as to produce in it a thin-line thermo-optical sound source. In the calculations of its radiation pattern according to the theory of thermo-optical excitation of longitudinal and transverse sound waves in solids, saddle points of the field integrals were taken into account using the apparatus of Green functions and the volume distribution of heat sources, but disregarding the not-so-significant surface heat sources. A comparison of theoretical and experimental results has yielded qualitative relations for the wave velocities as functions of wave numbers, angle, and Rayleigh determinant. The source penetration depth in the metal, much smaller than the wavelength of sound but finite, is found to detract from full compensation of forward waves by reflected ones. As the width of the laser beam is increased, moreover, the source tends to emit more preferentially longitudinal sound waves. Figures 1; references 5: 3 Russian, 2 Western.  
[559-2415]

#### RADIATION OF SOUND BY TURBULENCE NEAR A WALL

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 11, No 11,  
12 Jul 85 (manuscript received 6 Feb 85) pp 686-689

LYAMSHEV, L.M. and SKVORTSOV, A.T., Acoustics Institute imeni N.N. Andreyev,  
USSR Academy of Sciences

[Abstract] A universal relationship is demonstrated between acoustic and aerohydrodynamic characteristics of a turbulent stream near a wall (turbulent boundary layer), according to which the acoustic radiated power is proportional to the cube of the aerohydrodynamic resistance factor. It is concluded that the presence of polymer additives in the turbulent stream next to a wall decreases the power of acoustic radiation generated by the stream. The maximum of the effect is around 20 dB. References 8:  
7 Russian, 1 Western.  
[533-6508]

## SCATTERING OF ACOUSTIC WAVES BY A CIRCULAR LIQUID CYLINDER CONTAINING A LIQUID FILLER

Tallinn IZVESTIYA AKADEMII NAUK ESTONSKOY SSR: FIZIKA MATEMATIKA  
in Russian Vol 34, No 2, Apr-Jun 85 (manuscript received 3 Jan 84)  
pp 182-189

VEKSLER, N. and KARTASHOV, Yu., Institute of Cybernetics, Estonian Academy  
of Sciences; Northwestern Polytechnical Correspondence Institute

[Abstract] A study is made of a liquid cylinder containing a coaxial liquid filler struck by an acoustical pressure wave train, the plane front of which is parallel to the generatrix of the cylinder. The problem is to calculate the secondary, scattering field of acoustical pressure in the liquid and present a physical interpretation. The frequency and time variation of acoustical pressure back scattered by the cylinder is computed. The resonant nature of the scattering process is explained. An equation is derived for computation of the divergence of waves upon reflection in the cylindrical layer. Figures 5; references 3: 1 Russian, 2 Western [545-6508]

UDC (535/534:53.082.4)+535.21

## PHOTOACOUSTIC METHOD OF DETERMINING THERMOPHYSICAL CHARACTERISTICS, PART 2

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 49, No 1, Jan 85  
(manuscript received 21 Mar 84) pp 72-77

VINOKUROV, S.A.

[Abstract] The principle of photoacoustically determining the thermophysical characteristics of materials is outlined, such a determination involving the use of two layers of different materials with a negligible thermal resistance between them. One layer is a test specimen and the other layer is a reference specimen. The principal requirement is that the thermal diffusion length of the two layers be, respectively,  $a_1 l_1 < 1.5$  and  $a_2 l_2 > 1.5$  ( $l$  - geometrical length,  $a = (2\omega/\alpha)^{-1/2}$  - thermal diffusion coefficient,  $\omega$  - modulation frequency,  $\alpha$  - thermal diffusivity). It is then possible to determine the thermophysical characteristics from either the phase shift or the amplitude of the acoustic signal produced upon absorption of light at the various surfaces. The phase method is preferable, because it does not require that the heat sources at the various surfaces be of the same intensity or that their intensities be known when they are not equal. The key indicator in the phase method with the outer surface of the test specimen illuminated is the extremum through which the phase shift passes as function of  $a_2 l_2$ , this parameter characterizing the test specimen and its

thermal activity relative to that of the reference specimen. It is also possible to make a comprehensive determination by measurement of both phase and amplitude, in which case the sensitivity of the method will be determined by the amplitude measurements. The sensitivity generally depends on the relative thicknesses of the two layers as well as on their very thermophysical characteristics. Since intimate contact between layers is an essential requirement, use of a liquid as the thicker reference specimen will yield more reliable results. Figures 4; references 4: 2 Russian, 2 Western.  
[546-2415]

UDC 534.2+539.4

FOCUSING OF AN ELASTIC IMPULSE IN SOLID BODIES WITH DISLOCATION ACCUMULATIONS

Minsk VESTSI AKADEMII NAVUK BSSR: SERIYA FIZIKA-MATEMATYCHNYKH NAVUK  
in Russian No 6, Nov-Dec 85 pp 74-78

KLUBOVICH, V.V., KIRILLOV, S.A. and VAGAPOV, I.K.

[Abstract] Studies of elastic-plastic waves arising upon impact loading of solids have shown that the attenuation of the elastic precursor cannot be explained by the initial dislocation density in the crystal. The authors suggest that one possible reason for increasing dislocation density may be concentration of stresses as a result of focusing of the leading edge of the elastic precursor on microscopic heterogeneities in the specimen such as dislocation accumulations or inclusions of another phase. The rapid rise rate of stress in the leading edge of the elastic precursor indicates the presence in its spectrum of a high frequency acoustical harmonic, the length of which is less than the heterogeneity dimensions in the crystal. This work utilizes a space-time geometric optics method to solve the problem of propagation of a plane pulse in a flat stratified medium. It is demonstrated that focusing of the elastic precursor on accumulations of defects may cause an increase in the density of mobile dislocations, producing a high rate of relaxation of stresses behind the leading edge of the elastic wave and a change in the structure of the material resulting from ultrasonic processing. References 9: 3 Russian, 6 Western.  
[6508/106]

UDC 621.378.35

CALCULATION OF MECHANICAL STRESSES IN 'SEMICONDUCTOR LASER-HEAT SINK' SYSTEM

Minsk VESTSI AKADEMII NAVUK BSSR: SERIYA FIZIKA-MATEMATYCHNYKH NAVUK  
in Russian No 4, Jul-Aug 85 (manuscript received 27 Jan 84) pp 63-67

KUZMIN, L.N. and RYABTSEV, G.I., Institute of Physics, BSSR Academy of Sciences

[Abstract] The total mechanical stresses appearing in a semiconductor heterostructure, those produced during its buildup on the substrate plus those

produced during its mounting on the heat sink, are calculated with the anisotropy taken into account. First, the stresses before mounting are calculated, namely, the thermal ones in adjacent layers of different materials with different thermal expansion coefficients. The corresponding system of equations of force balance and moment balance, as well as of total displacements at the interlayer boundaries, is solved for the ternary system  $\text{Al}_x\text{Ga}_{1-x}\text{As}$ , assuming that the different layer materials have the same Young modulus, the error of this approximation being small, that the thermal expansion coefficient of  $\text{Al}_x\text{Ga}_{1-x}\text{As}$  depends linearly on the molar fraction of aluminum, namely,  $\alpha_x = \alpha_1 - x(\alpha_1 - \alpha_2)$  ( $\alpha_1$  - thermal expansion coefficient of GaAs,  $\alpha_2$  - thermal expansion coefficient of AlAs), and that the magnitudes of elastic strains in all layers are smaller than the heterostructure dimensions. Next, the stresses which appear during mounting on a heat sink are calculated. The relations between displacements and strains in the principal directions yield the independent components of the strain tensor and the generalized Hooke's law then yields the principal stresses; the tensor of principal stresses in an anisotropic heterogeneous structure being most expediently formulated as a diagonal one. The resulting expressions are applied, with appropriate numerical values, to a GaAs laser diode on a copper heat sink. When the strains in a laser diode are much smaller than its dimensions, then the total stresses can be obtained by adding pairwise the components of the two tensors which represent, respectively, stresses due to different thermal expansivities of the heterostructure layers and stresses due to mounting by soldering. The results of numerical calculations made for typical GaAs/AlGaAs heterostructures at room temperature have yielded average total stresses of 15 MPa and 77 MPa, depending on whether the n-region or the p-region is joined to the heat sink, both being higher than usual residual stresses of 5 MPa. At 273 K they decrease along the height of the structure to one-seventh or less at the top, which makes it preferable to joint the n-region to the heat sink. Both the largest component and the smallest component of the stress tensor in the active region are functions of the horizontal coordinates, with radial symmetry and monotonic radial profiles. An analogous symmetry exists in the vertical plane. The authors thank V.P. Gribkovskiy and V.K. Kononenko for discussing the results. Figures 2; references 12: 3 Russian, 9 Western (3 in Russian translation). [27-2415]

## CALCULATION OF HIGH ENERGY POSITRON AND ELECTRON RADIATION SPECTRA WITH FLAT CHANNELING IN DIAMOND-TYPE CRYSTALS

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA in Russian  
Vol 20, No 4, Jul-Aug 85 (manuscript received 20 Aug 83) pp 191-198

AVAKYAN, A.R. and YANSHI,

[Abstract] A number of works have developed the theory of radiation with planar channeling of relativistic particles in crystals. In nonparabolic models, it is practically impossible to achieve simple analytic expressions with a spectral-angular density of radiation intensity. The only applicable method is numerical integration of the equations of motion of the particles in a continuous plane potential, the method which is used in this work to calculate the radiation spectra of particles with energies on the order of  $10^9$ - $10^{10}$  eV and compare these spectra with the results of experimental measurements. Figures 3; references 10: 7 Russian, 3 Western.  
[6508/88]

## MODULATION OF OPTICAL RADIATION IN CRYSTALS BY COHERENT ULTRASONIC EXCITATION

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA in Russian  
Vol 20, No 4, Jul-Aug 85 (manuscript received 10 Jan 85) pp 234-236

KOCHARYAN, L.A., ARUTYUNYAN, E.M. and ARUTYUNYAN, G.A., Institute of Applied Physics Problems, Armenian Academy of Sciences

[Abstract] An experimental study is presented of the influence of spatial homogeneity (coherence) of ultrasonic waves in the area of acoustooptical interaction on the depth of modulation of optical radiation. The source of optical radiation studied was a helium-neon laser with wave length 0.63  $\mu$ m, output power 200  $\mu$ W. The acoustooptical medium was a crystal of lead molybdate. The piezoconverter was a quartz plate generating longitudinal ultrasonic waves at 10-35 MHz. Acoustical waves passing through the medium strike a gamma-resonant absorber in which the gamma-resonant radiation interacts with the ultrasonic phonons. Gamma resonance has a very narrow absorption line, and the slightest changes in acoustical wave parameters passing through the medium lead to changes in gamma-resonant absorption line parameters, allowing the degree of coherence of the acoustical field in the acoustooptical crystal to be monitored. Studies of the intensity of light in the diffraction maxima as a function of degree of coherence of the acoustical radiation showed that with otherwise equivalent conditions, 100% modulation depth requires great homogeneity or coherence of the acoustic field. Figures 2; references 3: 2 Russian, 1 Western.  
[6508/88]



## STUDY OF CdS SURFACE BY OPTICAL METHODS UPON ADSORPTION OF ORGANIC DYES

Moscow POVERKHNOST: FIZIKA, KHIMIYA MEKHANIKA in Russian No 7, Jul 85  
(manuscript received 22 Jun 84) pp 51-55

GETSKO, O.M., SNITKO, O.V. and YURCHENKO, I.A., Institute of Semiconductors,  
Ukrainian Academy of Sciences, Kiev

[Abstract] Adsorption and luminescence spectra were measured at 77 K on an installation based on two coupled MDR-23 monochromators with recording of the light signal by photon counting or synchronous detection. Dye adsorption was performed from aqueous solutions of rhodamine B and crystalline violet at  $10^{-7}$ - $10^{-3}$  mol/l, producing films of dye ranging from a fraction of a monolayer to several layers on the surface of the CdS. Adsorption of the dye from solutions at  $10^{-7}$  to  $10^{-5}$  mol/l produced molecules of dyes spread over the surface in isolation from each other, their dipole moments of absorption being oriented primarily in parallel to the surface of the specimen. At  $10^{-4}$  mol/l, dimers are formed on the surface of the CdS and the dipole moments of the dye molecules are reoriented perpendicular to the surface of the crystal. The quantum yield of luminescence of adsorbed molecules depends essentially on their orientation relative to the surface of the crystal. Figures 5; references 10: 9 Russian, 1 Western.  
[524-6508]

UDC 534.24

## INTERACTION SECTION OF ULTRASONIC WAVE AND STRUCTURAL DISLOCATIONS IN SOLID

Minsk VESTSI AKADEMII NAVUK BSSR in Russian No 2, Mar-Apr 85 (manuscript received 22 Mar 83) pp 100-103

KVASOV, N.T., Minsk Radio Engineering Institute

[Abstract] The scattering of an ultrasonic wave on a structural defect in a solid can be examined theoretically by solving the wave equation for the matrix and defect spaces with allowance for conditions at the defect-matrix interface. However, such an approach is extremely difficult mathematically and is inadequate per se. In seeking an easier and sounder solution, the author proposes a theory of ultrasound scattering which uses the concept of an effective interaction potential between an ultrasonic wave and a defect and a zero-angle scattering factor. The presented calculations reveal that application of this concept makes possible the most adequate inclusion of an arbitrary dislocation in the crystal lattice in the mathematical structure of the theory. The proposed approach makes it easy to obtain virtually all the phenomena related to ultrasound propagation in real crystals, such as velocity and attenuation changes and polarization effects. It is not

difficult to make allowance for transverse and mixed waves associated with scattering on a defect. Particular attention is given to the validity of application of the Born approximation used in this approach. It is concluded that this approximation is applicable in virtually the entire frequency range of ultrasound and acoustic oscillations in solids.

References: 7 Russian.

[399-5303]

UDC 621.315.592

# COMPLEX CENTER OF SCINTILLATING LUMINESCENCE IN ELECTRON-BOMBARDED CdS SINGLE CRYSTALS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 27, No 7, Jul 85 (manuscript received 12 Dec 83) pp 1921-1928

BOGDANYUK, N.S., GALUSHKA, A.P., OSTAPENKO, S.S. and SHEYNKMAN, M.K.,  
Institute of Semiconductors, UkSSR Academy of Sciences, Kiev

[Abstract] An experiment was performed with electron bombardment of CdS single crystals, a semiconductor material of the A<sup>II</sup>B<sup>VI</sup> group with wide forbidden band, which has demonstrated and thus confirmed the optical anisotropy of its "red" luminescence center. Single crystals grown from the melt under a pressure of 180 atm were bombarded with 1.2 MeV electrons in doses of  $10^{17}$ - $10^{18}$  cm<sup>-2</sup> at 200 K temperature. Measurements by the method of polarization diagrams have yielded not only the spectra of luminescence and its excitation but also the degree of polarization of both steady luminescence and scintillation, as a function of the angle between the polarization plane of the exciting light and the C-axis of the crystal. The results reveal the symmetry and the orientation of the optical dipole associated with radiative electron transitions in a complex luminescence center, confirming the theory of polarized luminescence of hexagonal crystals. A model of a complex center is proposed which includes an A-center ( $S_i$ ) and a D-center ( $V_s$ ) along with a K-center ("red"). The scintillation mechanism involves, accordingly, a transfer of electrons from A-centers to D-centers during illumination of the crystal at a wavelength within the pumping range and attendant tunneling of holes into K-centers. Recombination of electrons in D-centers and holes in K-centers is impeded by a potential barrier raised by the field of negatively charged A-centers but removable by photoexcitation of electrons from A-centers into the conduction band, with attendant illumination of the crystal at a wavelength within the scintillation stimulating range. Subsequent intercenter tunneling recombination is manifested as scintillation of "red" luminescence. Absence of changes in structure and symmetry of the complex luminescence center rules out the mechanism of photochemical breakup. Figures 4; tables 1; references 22: 13 Russian, 9 Western.  
[579-2415]

# STUDY OF $4f^25d$ CONFIGURATION OF $Nd^{3+}$ ION IN CRYSTALS BY METHOD OF ABSORPTION FROM EXCITED STATE

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 27, No 7, Jul 85 (manuscript received 28 Jan 85) pp 2194-2196

DUBINSKIY, M.A. and SMOLOV, A.L., Kazan State University

[Abstract] An experimental study of  $YAlO_3$  and  $YSiO_5$  crystals activated with  $Nd^{3+}$  ions was made for measurement of the cross-section for induced absorption of ultraviolet light, induced by  $4f^3-4f^25d$  transitions from the excited  $^4F_{3/2}$  state of the  $Nd^{3+}$  ion, and for monitoring the  $4f^25d$  configuration of that ion. The peak cross-sections in these crystals were found to be, respectively, one order of magnitude lower ( $0.2 \cdot 10^{-18} \text{ cm}^2$  at a frequency in the  $41,900 \text{ cm}^{-1}$  band) and one order of magnitude larger ( $2 \cdot 10^{-17} \text{ cm}^2$  at a frequency in the  $50,000 \text{ cm}^{-1}$  band) than that in YAG crystals ( $2 \cdot 10^{-18} \text{ cm}^2$  at a frequency close to  $33,300 \text{ cm}^{-1}$ ). The authors thank M.L. Meylman for interest and helpful discussions. Figures 1; references 8: 6 Russian, 2 Western.  
[579-2415]

# ROLE OF SURFACE SPACE CHARGE IN FORMATION OF SURFACE EXCITON IN SEMICONDUCTORS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 27, No 7, Jul 85 (manuscript received 2 Jan 85, in final version 4 Mar 85) pp 2231-2233

ZINETS, O.S., Institute of Nuclear Research, UkSSR Academy of Sciences, Kiev

[Abstract] The energy of a Vanier-Mott exciton localized within the surface space-charge layer in a semiconductor is calculated, taking into account the image forces, as well as the momentary force of repulsion at boundaries, and assuming a space-charge region much wider than the exciton radius. The behavior of such an exciton in an electric field whose potential varies sufficiently smoothly and slowly within distances comparable with the exciton radius is described by the appropriate Schrödinger equation, that behavior being characterized by the exciton losing energy on generating a potential well for its motion as an entity. The almost linear dependence of energy levels of a surface exciton on the surface potential has been evaluated numerically for typical conditions in a CdS crystal with an impurity concentration of  $n = 2 \cdot 10^{16} \text{ cm}^{-3}$ , considering that the exciton energy at any potential is proportional to the impurity concentration. Figures 1; references 9: 7 Russian, 2 Western.  
[579-2415]

## ENERGY TRANSFER IN SOLID BODIES; NEW ACTIVE MEDIA FOR SOLID STATE LASERS

Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 146, No 2, Jun 85 pp 355-357

SHCHERBAKOV, I.A.

[Abstract] This paper represents a summary of a report presented on 29 November 1984 at the scientific session of the Department of General Physics and Astronomy and the Department of Nuclear Physics of the USSR Academy of Sciences at the Physics Institute imeni P.N. Lebedev. The current status of nonradiant transfer of electron excitation energy in dielectric crystals and glasses is discussed. The theory of static transfer and the theory of hopping extinction of luminescence are found to agree quantitatively with experimental findings on the interaction of the ions of rare-earth and transition elements in laser crystals. General principles are established that connect the microscopic interion interaction mechanisms with energy relaxation processes in a group of interacting particles. Ways are demonstrated to increase the energy density stored in the laser active medium by more than an order of magnitude. Figures 2.  
[521-6900]

UDC 621.373.826.038.825.3

## TESTS OF SEVERAL NEODYMIUM GLASSES FOR COMPARISON OF THEIR LASING CHARACTERISTICS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 18 Apr 84) pp 694-697

BERZINA, G.D., BORIK, M.A., BUZHINSKIY, I.M., DENKER, B.I., GULYAMOVA, E.S., ILICHEV, N.N., KORYAGINA, Ye.I., MALYUTIN, A.A., OSIKO, V.V., PASHININ, P.P. and SURKOVA, V.F., Institute of General Physics, USSR Academy of Sciences, Moscow

[Abstract] Several glasses for neodymium lasers of USSR manufacture were tested for a comparative evaluation of their lasing characteristics. The phosphate glasses included grades KNFS, KGSS083, KGSS0102, KGSS0116, KGSS0125, LGST, LGS55-5, LGS55-7, GLS22P, GLS24P, OPS1721 (corded). The silicate glasses included grades LGS59-5, LGS61, GLS8. Also included in the tests was a YAG:Nd<sup>3+</sup> cell. All were tested in free emission, monopulses and periodic pulses, as well as with Q-switching of monopulses by means of an electrooptic shutter. The active cells for these tests, 4.5-6.3 mm in diameter and 65-102 mm long, were subdivided into two groups for testing with different shutters. The other test equipment was the same for all: silverized quartz luminaire, ISP-2500 pumping flashlamp, distilled water for cooling without cutting off ultraviolet radiation from the flashlamp, discharge circuit consisting of 100  $\mu$ F capacitor and 33  $\mu$ H coil, 25 cm long

resonator with 100%-reflection plane mirror and 63%-reflection spherical (5 m radius) exit mirror. With the neodymium concentration appropriate for each glass, after determining the lifetime of the  ${}^4F_{3/2}$  level and the emission energy, measurements were made of the average pumping power at breakdown of the active cell and the maximum average laser output power. Probing of the thermal lens inside the active cell with collimated radiation from a He-Ne laser was done to determine its focal length at various levels of pumping power (59-300 W) in the free periodic-pulse emission mode. Measurements were also made of the pumping power necessary for attainment of given output energy levels (50-150 mJ) in the Q-switching mode. Extra tests were performed with Q-switching of giant emission pulses by means of an LTI-5 laser through a DKDP crystal shutter, using a 20  $\mu$ F capacitor and a 50 cm long resonator. The KNFS glass was found to offer the best overall performance characteristics, particularly highest efficiency and average output power, in either free emission or Q-switching mode. Other glasses were found to come close in either efficiency or average output power, and even then only for one particular mode of operation. The authors thank V.G. Ostroumov for measuring the lifetime of the upper lasing level in these glasses. Figures 3; references: 6 Russian.  
[456-2415]

INVESTIGATION OF STRUCTURES OF HIGH FREQUENCY NONINDEPENDENT DISCHARGE IN GAS STREAM

Moscow FIZIKA PLAZMY in Russian Vol 11, No 7, Jul 85 (manuscript received 6 Sep 84 after revision) pp 882-888

KOVALEV, A.S., MURATOV, Ye.A., OZERENKO, A.A., RAKHIMOV, A.T. and SUYETIN, N.V., Scientific Research Institute for Nuclear Physics, Moscow State University

[Abstract] The structure of high frequency nonindependent discharge in a gas stream is investigated, and experimental setup is described in which a stationary discharge is excited at 25 MHz in a nitrogen stream with pressure varying from 50 to 150 Tor. It is found that a nonindependent high frequency discharge in a gas stream makes it possible to increase the maximum energy contribution to the gas as compared with a direct current discharge, and to realize that energy contribution for optimal values of the parameters  $E/p$  and minimum densities of the external ionizer. The advantages of nonindependent discharges are important for development of high-speed gas lasers and plasma chemical systems. Figures 6; references: 12 Russian. [532-6900]

EROSION OF PULSE FRONT OF RELATIVISTIC ELECTRON BEAM IN NEUTRAL GAS

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 55, No 7, Jul 85 (manuscript received 5 Jul 84) pp 1465-1467

MKHEIDZE, G.P., SAVIN, A.A. and SOROKIN, G.A., Institute of General Physics, USSR Academy of Sciences, Moscow

[Abstract] Changes in the shape of a relativistic electron beam upon entering a neutral gas are interpreted in terms of the charge compensation mechanism. An experiment with injection of such an electron beam from the "Terek-1R" accelerator into a dense gas has confirmed this mechanism of pulse front erosion. An electron beam of 1.5 MeV energy and 12 kA - 40 ns current pulses was injected into a 120 cm long metal chamber 12.8 cm in diameter containing an  $N_2:SF_6 = 6:1$  gas mixture under a pressure which was

varied over the 100-750 torr range. The resulting pulse front erosion was caused by appearance of a radial drift velocity under a pressure sufficiently high to make the mean free path of electrons smaller than the beam radius. The mechanism is mathematically described in the paraxial approximation, corresponding to a current below the Alfvén level, for an electron beam with equilibrium charge compensation and self-focusing. Pressure dependence of the neutralization time, especially strong in the low-pressure range, is taken into account. The estimates agree closely with earlier ones for a medium with a constant electrical conductivity. Figures 3; references 11: 9 Russian, 2 Western.  
[545-2415]

UDC 539.12.01(048)

#### GAS KINETICS IN LASER RADIATION FIELD

Novosibirsk AVTOMETRIYA in Russian No 1, Jan-Feb 85 (manuscript received 20 Jul 84) pp 49-77

GELMUKHANOV, F.Kh.

[Abstract] The theoretical foundations of gas kinetics in a radiation field are presented, and rigorous methods of classical gas kinetics are explained. The gas kinetic equations for a laser radiation field are given. The physical mechanism underlying light-induced drift is explained. The characteristics of diffusion processes and thermodiffusion in a laser radiation field are analyzed. The place of light-induced drift and the effects stemming from it is established among other physical effects; the general principles of light-induced drift and its most important manifestations are identified. References 68: 61 Russian, 7 Western.  
[377-6900]

UDC 621.175:541.182.2

#### ENLARGEMENT OF AEROSOL PARTICLES THROUGH CONDENSATION DURING MIXING OF GAS AND VAPOR

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 49, No 1, Jan 85 (manuscript received 15 Jun 84) pp 18-22

SUGAK, Ye.V., Siberian Institute of Technology, Krasnoyarsk, and ISAKOV, V.P., Leningrad Institute of Technology imeni Lensovet

[Abstract] Mixing of ventilator air or exhaust gas with vapor is considered as an energy-efficient method of air purification by the mechanism of condensation with attendant enlargement of aerosol particles. For an analysis of this process in a two-phase system, the necessary initial supersaturation

beyond the critical level is described on the basis of the Kelvin equation, and the subsequent condensation is described on the basis of the Clausius-Clapeyron equation. The resulting system of equations, including also the equation of heat balance, is solved for the ratio of condensate mass to dry gas mass and the final vapor concentration. Both then yield the diameter of aerosol particles after mixing and the temperature of the gas-vapor mixture. An experiment was performed with air and water vapor in a thermally insulated cylindrical mixing chamber. The air was intentionally contaminated with various dust materials, such as M-1 quartz powder, zinc oxide, phosphorite, or soot, particles 0.1-10  $\mu\text{m}$  in diameter with a bulk density of 1000-2000  $\text{kg/m}^3$ . The condensate was extracted from the mixture by means of a centrifugal separator with a whirler coil and a Petryanov filter. The final size of essentially monodisperse aerosol particles was found to be determined principally by the amount of condensate building up on their surface and not significantly by their initial size. Figures 2; references 12: 5 Russian, 7 Western (2 in Russian translation). [546-2415]

UDC 533.72+541.124/128+541.10

#### ROTATIONAL RELAXATION IN GASES: SURVEY

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 49, No 1, Jan 85  
(manuscript received 12 Jul 84) pp 154-170

OSIPOV, A.I., Moscow State University imeni M.V. Lomonosov

[Abstract] Theoretical and experimental research pertaining to rotational kinetics in gases was stimulated by developments in laser physics and laser chemistry during the past two decades. The principal aspect of rotational kinetics is relaxation of the mean energy, characterized by a time factor and intimately associated with collision kinetics with conservation of momentum and of angular momentum constraining both. The nonequilibrium distribution of molecules with respect to rotational energy, on which the relaxation process depends, is theoretically determined from the equations of gas kinetics for the population of rotational levels. The classical distribution  $f(\epsilon, t)$  in the energy-time domain is adequate for most gaseous substances so that quantization of rotational energy can be disregarded, in the Smolukhovskiy integro-differential formulation or in the Fokker-Planck diffusion approximation for both extreme cases of adiabatic and nonadiabatic collisions. Next, compound translational-rotational relaxation, along with resonant vibrational-rotational exchange and rotational-translational exchange, both characterized by quasi-steady distribution functions, have been examined. Rotational relaxation, including also rotational-rotational exchange, has been studied in single-component gases and in polyatomic molecules. Important practical applications in physical and chemical processes are rotational nonequilibrium and relaxation in products of chemical reactions, in a radiation emitting gas, in an expanding gas stream, in shock waves, and during absorption of infrared laser radiation by molecular gases. Figures 1; references 49: 29 Russian, 20 Western. [546-2415]



RELATIVISTIC THEORY OF SUPERFLUIDITY: PHENOMENOLOGICAL APPROACH

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 6, Jun 85 (manuscript received 31 May 84) pp 58-61

FOMIN, P.I. and SHADURA, V.N., Institute of Theoretical Physics, UkSSR Academy of Sciences, Kiev

[Abstract] The relativistic theory of superfluidity is considered from the phenomenological standpoint according to Landau. It is constructed for a quantum system at local equilibrium below the critical point, with the coexisting macroscopic normal "excitations gas" and superfluid "condensate" components each characterized by a conservative "charge" density and a velocity field. The superfluid velocity is related to the phase gradient through the effective "wave function" of the condensate. A system of equations is derived which includes the energy-momentum tensor, as well as two scalar functions, one being the temperature and one being related to the relative velocity between the two components, in the nondissipative approximation. In order for this system to be consistent, it is necessary that certain relations between those two scalars be satisfied. These relations then determine the Lorenz-invariant thermodynamics of the system. Subsequent analysis reveals no contradiction with the Landau nonrelativistic theory of superfluidity with zero entropy, inasmuch as the nonrelativistic limit of entropy is zero according to the Nernst theorem. Article was presented by Academician (UkSSR Academy of Sciences) V.G. Baryakhtar. References 12: 8 Russian, 4 Western (1 in Russian translation). [557-2415]

UDC 621.373.826.038.825.2

REFLECTION OF PULSED RADIATION FROM RUBY LASER BY COPPER TARGET IN AIR OR IN VACUUM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 10 May 84) pp 749-754

VOROBYEV, A.Ya., Kharkov State University imeni A.M. Gorkiy

[Abstract] An experimental study of reflection of high-intensity laser radiation by metal targets was made for the purpose of determining the reflection coefficient and the effect of the plasma shield above the metal surface. A ruby laser was used as radiation source emitting pulses of 45 ns duration and 0.5 J energy. These were focused on a target made of M1 copper, within a spot 1.8 mm in diameter so as to ensure a nearly plane interaction geometry, with the radiation intensity varying not more than  $\pm 35\%$  over the beam cross-section. The target had been pretreated with laser radiation of an intensity above the surface melting threshold. Measurements were made by the method of hollow elliptical reflection in air and in a vacuum of 0.06 mm Hg, with an optical pyrometer operating in the  $530 \pm 5$  nm wavelength band and calibrated against an SIRSh 6-100 standard temperature-scale lamp. The optical thickness of the plasma layer  $k = -\log [P_2(t)/P_1(t)]$  was measured by the method of longitudinal trans-illumination on the basis of output power  $P_2(t)$  and input power  $P_1(t)$  readings,  $P_2(t)$  being measured with a photoreceiver behind a hole 0.16 mm in diameter in the target. Measurements and calculations were also made on the basis of the Drude-Zener theory and thermal interaction, disregarding the size effect. The results reveal that the reflection coefficient is much lower in air than in vacuum, this being hypothetically attributable to an ionization layer of copper vapor forming in air. The author thanks M.N. Libenson for many discussions and helpful suggestions. Figures 4; references 19: 12 Russian, 7 Western.  
[456-2415]

## CHARACTERISTICS OF COHERENT RADIATION REFLECTED BY ROUGH SURFACE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 14 May 84) pp 767-771

USTINOV, N.D., ANUFRIYEV, A.V., VOLPOV, A.L. and ZIMIN, Yu.A.

[Abstract] Reflection of coherent radiation by a rough surface is analyzed theoretically, taking into account cooperative secondary emission of radiation by such a surface or rather its partial correlation regions. The process of secondary emission is described by the Maxwell equations for material oscillators excited by a coherent incident electromagnetic field, assuming that the surface material is a dielectric which absorbs negligibly at the frequency of this field. Describing the interaction of radiation and surface material in the linear dipole approximation with allowed transitions and subsequent averaging over a volume larger than the wavelength cubed yield the classical second-order integro-differential equation for the polarization of the material. The incident field is then assumed to be a monochromatic one with a plane wavefront and linear polarization  $E = E_x e^{i\omega t}$ , while the surface is assumed to be a one-dimensional one  $z = M(x) + h(x)$  consisting of a deterministic macrocomponent  $M(x)$  and a random microcomponent  $h(x)$ . The corresponding equations are solved upon introduction of the probability density function characterizing the distribution of random boundaries  $w(h)$  and random slopes  $w(h_x)$ . The results reveal that the mean dimension of correlation regions and the amplitude of reflected radiation near the surface depend, respectively, on the correlation radius of surface roughness and on the transverse profile of surface roughness. The initial phase of reflected radiation is analogous to the random phase in the Kirchhoff approximation, proportional to the mean phase of the wave aggregately reflected by a correlation region. The polarization of reflected radiation is proportional to and thus determined by the slope of the macrosurface  $M(x)$ . These conclusions have been confirmed experimentally by irradiation of a rough surface with a laser beam through a polaroid and a set of neutral filters, visual observation having been made, and photographs with a camera having been taken through a microscope with x120 magnification and a matched polaroid. Figures 2; references 7: 6 Russian, 1 Western.

[456-2415]

## EXPERIMENTAL STUDY OF LUMINESCENCE OF HOT ELECTRONS IN METALS

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 49,  
No 7, Jul 85 pp 1430-1434

AGRANAT, M.B., ASHITKOV, S.I., OVCHINNIKOVA, I.B. and TAURIN, N.F.,  
All-Union Scientific Research Institute of Optical Physical Measurements

[Abstract] An experimental study was made on the heating of free electrons in metals by picosecond laser pulses and the attendant luminescence of hot electrons. The main experiments were performed with radiation pulses of several millijoules energy and 20-40 ps duration from a YAG:Nd<sup>3+</sup> laser with passive mode locking, two amplifiers, and a monopulse extractor. The time characteristics of electron luminescence within the 0.56-0.72  $\mu\text{m}$  range of wavelengths were measured with an "Agat" photochronograph, this instrument having a time resolution of 5 ps and a sensitivity of  $10^{-11}$ - $10^{-10}$  J/cm<sup>2</sup>. Scattered light at the fundamental laser wavelength (1.06  $\mu\text{m}$ ) and second-harmonic emission from the metal surface (0.53  $\mu\text{m}$ ) were completely eliminated as factors influencing the measurements. The laser pulse parameters were monitored by means of an auxiliary photochronograph. The spectral characteristics of electron luminescence were measured with two FEU-79 photomultipliers, at two wavelengths within the visible region notched out by a narrow-band interference filter and an MDR-2 diffraction monochromator. The luminescence temperature was measured as the color temperature on the basis of the blue-to-red (0.43  $\mu\text{m}$ :0.70  $\mu\text{m}$ ) ratio. Luminescence of hot electrons was induced in metal films as thin as 500 Å thick and in metal slabs, with silver films serving as the principal specimens. The experiments yielded data on the background luminescence and the lattice temperature as well, indicating that efficient knockout of electrons at temperatures within the 300-8000 K range raises the electron temperature appreciably, by 100-300 K, above the lattice temperature and that the electron temperature then governs the luminescence. Figures 4; references 6: 5 Russian, 1 Western  
[560-2415]

## FORMATION OF PERIODIC MICRORELIEF ON THE SURFACE OF TRANSPARENT BODIES UNDER THE INFLUENCE OF LASER RADIATION

Moscow POVERKHNOST: FIZIKA, KHIMIYA, MEKHANIKA in Russian No 7, Jul 85  
(manuscript received 17 Apr 84) pp 93-98

GOLUBENKO, G.A., MASLENNIKOV, V.L., PROKHOROV, A.M., SYCHUGOV, V.A. and TISHCHENKO, A.V., Institute of General Physics, USSR Academy of Sciences, Moscow

[Abstract] The effectiveness of periodic structure formation on the surface of transparent materials is calculated as a function of the incident angle of radiation, polarization, and index of refraction of the medium. The calculations show that when laser radiation strikes transparent media, periodic microstructures may form on their surfaces, primarily transverse. The results confirm the diffraction mechanism of formation of the periodic microstructures on the surfaces of transparent media and demonstrate the usability of a method of studying the effect of laser radiation on the surfaces of solids presented in an earlier work by the same authors. Figures 4; references: 5 Russian.  
[524-6508]

UDC 621.378.325+535:530.182

## EFFECT OF HIGH-POWER LASER RADIATION ON SURFACES OF SEMICONDUCTORS AND METALS: NONLINEAR OPTICAL EFFECTS AND NONLINEAR OPTICAL DIAGNOSIS

Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 147, No 4, Dec 85 pp 675-745

AKHMANOV, S.A., YEMEL'YANOV, V.I., KOROME'EV, N.I. and SEMINOGOV, V.N., Moscow State University imeni M.V. Lomonosov

[Abstract] This review defines the shape of a rapidly growing group of physical phenomena related to the excitation of strongly nonequilibrium states in the surface layers of metals, semiconductors, and dielectrics by high-power pulsed laser radiation; particular accent is placed on the significance of the nonlinear response of the material in the occurrence and diagnosis of these states. Absorption and relaxation of laser pulse energy and resultant heating of the lattice of materials is studied, as well as the various linear and nonlinear optical methods used to record laser-induced phase transformations on the surfaces of condensed media. Nonlinear optical processes resulting from modulation of the relief and surface temperature of condensed media are discussed. Modern laser technology has practically solved the problem of excitation and recording of nonequilibrium states in condensed media and has approached the natural limit of the optical response speed of such media determined by the duration of one optical field cycle. The technology now allows application of significant quantities of

energy to the electron subsystem of the surface layers of crystalline materials in a period of about  $10^{-14}$  s, followed by detailed tracing of the many stages of the transition of this energy to ordinary thermal excitation of the crystalline lattice and the subsequent cascade of phase transformations occurring on the surface. Experiments involving laser annealing of semiconductors using nanosecond and picosecond pulses have now been quantitatively explained. Defect formation in semiconductors may be caused by nonlinear optical instability of deformations. Under certain conditions, this mechanism may cause very fast (nonthermal) melting of the surface of a semiconductor. Clear pictures of changes in the external form of silicon surface areas irradiated with powerful femtosecond pulses have been taken at time intervals of about 100 fs by stroboscopic photography. Figures 29; references 216: 46 Russian, 170 Western.  
[6508-105]

UDC 621.536.592

#### DYNAMICS OF PHASE TRANSFORMATION IN SEMICONDUCTORS UNDER LASER IRRADIATION

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 49, No 1, Jan 85  
(manuscript received 30 Jan 84) pp 132-136

OSEREDKO, S.A., Lvov Polytechnic Institute

[Abstract] Laser treatment of semiconductors is analyzed on the basis of the appropriate equation of transient heat conduction, which takes into account phase transformations, as well as the temperature dependence of their optical and thermophysical properties. The laser energy is assumed to be transferred instantaneously and in the form of heat to the semiconductor lattice, from where it then spreads through the material by heat conduction only. Diffusion of hot charge carriers is disregarded. The equation is solved analytically for the appropriate initial and boundary conditions with respect to melting and recrystallization, their fronts and rates of propagation. From the corresponding heat balance are obtained, approximately, the minimum density of laser pulse energy which will cause melting of the semiconductor material and the maximum penetration depth of the melting front. Numerical calculations pertaining to laser annealing of germanium, silicon, and gallium arsenide have been made for laser radiation wavelengths of 0.53-1.06  $\mu\text{m}$  and laser pulse durations of 20-50 ns. Figures 1; tables 3; references 5: 2 Russian, 3 Western.  
[546-2415]

## LASERS

### NUMERICAL ANALYSIS OF MIXING EFFECTS IN CHEMICAL OXYGEN-IODINE LASER

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEVEDEVA  
in Russian Preprint No 115, 1984

AZYAZOV, V.N., IGOSHIN, V.I., KUPRIYANOV, N.L., NEMKOVA, T.Yu. and  
SIROCHENKO, V.P.

[Abstract] Mixing in the active medium of a chemical oxygen-iodine laser is analyzed numerically, with particular emphasis on diffusion, considering the high-energy singlet molecular oxygen (2400 J/g at a 100%  $O_2(^1\Delta)$ -content), as well as the active medium with a high gain ( $10^{-1} + 1$ )  $m^{-1}$  over a long inversion zone necessary for efficient and directional conversion. The physico-chemical model of the active medium with electronic excitation of molecular oxygen is based on the reaction  $Cl_2 + H_2O_2 + 2NaOH \rightarrow O_2(^1\Delta) + 2NaCl + 2H_2O$ . The mathematical model of diffusion in the free layer includes two partial differential equations describing the boundary layers of the two gas streams, respectively, with the appropriate conditions corresponding to a stream with periodic structure along the flow axis, also the equation of gas dynamics with transverse expansion and the equation of continuity in the "quasi-two-dimensional" approximation. After an expedient change from a system of three space coordinates  $x, y, z$  to one of two  $\xi = x, \psi(y, z)$ , this system of equations is solved by first applying the symmetric Crank-Nicolson scheme of finite differences to the model problem for the nonlinear equation  $\frac{\partial u}{\partial \xi} = \frac{\partial}{\partial \psi}(u \frac{\partial}{\partial \psi})$ . An advantage of the scheme is that it does not require "quenching" high-frequency perturbations. On the basis of given input data on transitions in the molecules and reactions in the mixture, a series of numerical tests has yielded the profiles of absorption coefficient and gain under various pressures (0.66, 1.33, 1.99 kPa) in the resonator space for oxygen and iodine in 100:1 molar ratio, with iodine vapor at a temperature of 320 K carried by nitrogen as buffer gas at an inlet velocity of 120 m/s and oxygen entering at a velocity of 100 m/s. Calculations were made for various ratios of nitrogen nozzle width to oxygen nozzle width (1, 1.3, 1.5) and various temperatures of the cooled oxygen trap (220, 245, 260 K), with the flow rate of nitrogen approximately equal to the flow rate of oxygen. Figures 5; references 16: 4 Russian, 12 Western (1 in Russian translation).  
[437-2415]

## CHEMICAL LASERS ON PHOTON-BRANCHING CHAIN REACTIONS

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 121, 1984

BASOV, N.G., IGOSHIN, V.I., KATULIN, V.A., ORAYEVSKIY, A.N. and PICHUGIN, S.Yu.

[Abstract] The known method of producing free atoms for a chemical infrared pulse laser is based on nonresonant interaction of infrared radiation with a substance such as hydrogen fluoride. Another approach is using resonant interaction of infrared radiation with a substance, such as methyl fluoride, which resonantly absorbs radiation at the 9.55  $\mu\text{m}$  wavelength from a  $\text{CO}_2$ -laser. A reaction between  $\text{CH}_3\text{F}$  and  $\text{F}_2$  molecules produces free fluorine atoms so that it can be used as trigger for a photon-branching chain reaction in the medium of a DF- $\text{CO}_2$  laser. The chemical processes and the energy characteristics of the resulting laser have been evaluated theoretically but without experimental verification. From the feasibility standpoint, therefore, other ways need to be considered, such as injection of a disperse solid substance into the medium of a DF- $\text{CO}_2$  laser. Particles of sodium azide are eminently suitable for this purpose, since they dissociate under heat and metallic sodium then reacts with fluorine molecules so as to produce free fluorine atoms according to the reaction  $\text{Na} + \text{F}_2 \rightarrow \text{NaF} + \text{F}$ . The dynamics of the subsequent photon-branching reaction and the energy characteristics of the resulting laser have been analyzed and evaluated on the basis of four systems of equations describing, respectively, the chemical kinetics, the relaxation of vibrational quanta, the heat balance, and the radiation emission rate in an 8-component medium ( $\text{D}_2$ , D,  $\text{F}_2$ , F, DF,  $\text{O}_2$ ,  $\text{CH}_3\text{F}$ ,  $\text{CH}_2\text{F}$ ), with the aid of available numerical data. (Figures 4; tables 3; references 18: 16 Russian, 2 Western.  
[437-2415]

## NUMERICAL MULTIPARAMETRIC OPTIMIZATION OF $\text{D}_2\text{-F}_2\text{-CO}_2$ CHEMICAL PULSE LASER

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 167, 1984 KVANTOVAYA RADIOFIZIKA

BAYKOV, E.U., BASHKIN, A.S., GAMZATOV, N.M., ORAYEVSKIY, A.N. and  
PORODINKOV, O.Ye., Quantum Radiophysics Laboratory

[Abstract] For the purpose of exploring the capabilities of  $\text{D}_2\text{-F}_2\text{-CO}_2$  lasers and at the same time reconciling theoretical calculations with laboratory results obtained so far, the performance of such a laser operating in the pulse mode was optimized in a numerical experiment with respect to maximum realizable output energy density and physical efficiency. The mathematical model contained six equations of chemical kinetics, four equations of vibrational relaxation, an equation of heat balance for the gas temperature, and an equation of laser dynamics for the radiation intensity in the resonator. Vibrational relaxation was described through vibrational states



of  $\text{CO}_2$  molecules, as had been done in models of  $\text{CO}_2$ -lasers with other pumping mechanisms, rather than conventionally by equations of relaxation microkinetics or by equations of energy relaxation. The optimizable parameters were composition of the active mixture  $[\text{D}_2]$ ,  $[\text{F}_2]$ ,  $[\text{CO}_2]$ ,  $[\text{He}]$  with or without  $[\text{O}_2]$ , initial temperature of the mixture  $T_0$ , total pressure of the mixture  $P_0$ , trigger level  $\alpha = \Delta[\text{F}_2]/[\text{F}_2]$ , and resonator coupling coefficient. These parameters were varied over ranges corresponding to technological feasibility, rather than over arbitrarily wide ranges, which saved an appreciable amount of computer time. Accordingly, the trigger level was varied over the 0-10% range (including the experimentally obtained 6.3%). The initial temperature was varied over the 340-200 K range, since  $\text{CO}_2$  gas begins to condense at temperatures below that, and the total pressure was varied over the 0-10 atm range. The nearly optimum ratio  $[\text{D}_2]:[\text{F}_2]$  was found to be 1:2, corresponding to the maximum output energy density  $e_L = f([\text{CO}_2])$  as function of the  $\text{CO}_2$  content. Calculations were made for several  $\text{D}_2:\text{F}_2:\text{CO}_2:\text{He}:\text{O}_2 = 3:6:x:(28-x):0.3$  or  $3:6:x:(29-x):0.3$  ( $x = 12-21$ ) mixtures and compared with data on mixtures without oxygen. The results indicate that the presence of oxygen degrades the energy characteristics of these lasers, while increasing the  $\text{CO}_2$  content plays a major role in improving the laser performance by first increasing the rate of V-V exchange interaction and then increasing the specific heat of the mixture. The optimum reflection coefficient  $R_1$  of the resonator mirror for maximum output energy density depends on the internal resonator losses  $\gamma$  and decreases as the latter increase, to approximately  $R_1 = 0.7$  at the  $\gamma = 7\%$  level. Both optimum initial temperature and total pressure of the mixture depend on the trigger level, the former increasing and the latter decreasing while the corresponding maximum output energy density decreases as the trigger level is decreased typically from 0.08% to 0.02%. The role of the trigger level was also evaluated in terms of the  $e_L \cdot \eta_{ph}$  product of output energy density and physical efficiency,  $e_L = 120 \text{ J/dm}^3$  and  $e_L = 180 \text{ J/dm}^3$  appearing to be attainable in the oscillator mode and in the saturated-signal amplifier mode, respectively, with a physical efficiency  $\eta_{ph} = 2500-4000$  and a technical efficiency  $\eta_t = 65\%$  to almost 100% being possible. Figures 8; tables 2; references 22: 19 Russian, 3 Western (1 in Russian translation). [437-2415]

#### EFFECTIVE PASSIVE SHUTTER FOR NEODYMIUM-GLASS LASERS WITH MODE SELF-LOCKING

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 171, 1984 KVANTOVAYA ELEKTRONIKA

BABENKO, V.A., MALYSHEV, V.I. and SICHEV, A.A.

[Abstract] A passive shutter with fast relaxing dye solution for ultrashort-pulse neodymium glass lasers has been developed and its design then optimized to ensure long life for stable emission. The design is based on theoretical analysis and experimental evaluation. The relaxation time is minimized and

an additional channel for fast quenching of the excited state by the superluminescence mechanism appears in a sufficiently thin vessel much shorter than the diameter of the laser beam. Such a vessel geometry also lowers the probability of parasitic effects, such as self-focusing, phase self-modulation, absorption of radiation by the solvent, and stimulated Mandelshtam-Brillouin or Raman scattering, all of which impede self-locking of modes and increase the resonator losses. Most effective shutter dyes for shaping picosecond pulses at the  $1.06 \mu\text{m}$  wavelength have been found to be No 3282-u and No 3323-u, as well as No 3955 nitrobenzene. The optimum thickness of the dye layer has been found to be  $100 \mu\text{m}$ , viscosity here ensuring a flow rate more uniform than in a still thinner layer, with its optimum initial transmission coefficient within the 0.6-0.8 range. The shutter vessel consists of two circular wedges made of K-8 glass 50 mm in diameter and placed on an optical mount, with a "dull" plane mirror consisting preferably of  $\text{SiO}_2$  and  $\text{TiO}_2$  layers across the center. A small turbine-stirrer with a 6-blade runner, made of chemically inert low-friction Teflon with a Sa-Co magnet bar pressed in, is placed in a cylindrical recess in the lower part of the vessel and driven by a small electric motor with a bar of any magnetic alloy through a contactless (magnetic) coupling. The authors thank Ye.N. Sirotin, N.S. Zaprudnov, and N.Ye. Shchelkalin for developing the shutter technology and producing the shutter prototypes; also S.I. Sagitov for producing the high-strength dielectric mirrors, and R.A. Shavrina for drawing the blueprints. Figures 10 (blueprints); references 18: 13 Russian, 5 Western. [437-2415]

#### SMALL-SIGNAL GAIN AND SATURATION FACTOR OF WAVEGUIDE LASER WITH DISTRIBUTED LOSSES

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 206, 1984 KVANTOVAYA ELEKTRONIKA

DUBOVSKIY, P.Ye., LOTKOVA, E.N., PONOMAREV, D.I. and SOBOLEV, N.N.

[Abstract] The small-signal gain and the saturation factor of a gas-discharge waveguide laser are calculated by calibration of losses on the basis of emission power measurements. Distributed losses and large-signal gain, both assumed to be uniform in a waveguide of uniform cross-section, are taken into account axially. The radiation intensity in each of two opposite directions decreases monotonically from one end to the opposite end, but their product remains constant along the waveguide. With the radiation intensity levels at each waveguide end fixed, thus under constant boundary conditions, the resultant intensity at any point along the waveguide and the saturation intensity can be replaced with the power at that point and the saturation power, respectively. Calculations for a CO-laser with the resonator mirror directly adjacent to the waveguide containing the active medium yield results which agree closely with experimental data, much closer than the results of calculations without the distributed losses. Both

small-signal gain and saturation factor become overestimated in the latter case. The results indicate also that increasing the length of the active medium (waveguide) reaches a point of diminishing returns, beyond which the power increases less than commensurately and the efficiency decreases. The authors thank A.S. Rasskazov for participating in the experimental determination of the small-signal gain. Figures 2; tables 2; references 6; 2 Russian, 4 Western.  
[437-2415]

THE LASER STRENGTH OF ACTIVE ELEMENTS MADE OF GADOLINIUM-SCANDIUM-GALLIUM  
GARNET (GSGG)

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 2, Feb 85 pp 430-432

[Article by Yu.K. Kanileyko, Ye.V. Zharikov, V.V. Laptev, Yu.P. Minayev,  
V.N. Nikolayev, A.V. Sidorin, G.N. Toropkin, and I.A. Shcherbakov,  
Institute of General Physics of the AN SSSR, Moscow]

[Text] The problems of the beam strength of the promising GSGG:Cr<sup>3+</sup>, Nd<sup>3+</sup> crystals were examined for the first time. It is demonstrated that their high laser strength is not susceptible to  $\gamma$ -radiation. Based on studies of damage statistics, it is concluded that microdefects play the decisive role in the damage of GSGG:Cr<sup>3+</sup>, Nd<sup>3+</sup> crystals.

In works [1-3] it was demonstrated that the output characteristics of neodymium (Nd) lasers working in both the burst and the pulse modes can be significantly improved by replacing the widely-used YAG:Nd<sup>3+</sup> crystal with GSGG activated by Cr<sup>3+</sup> and Nd<sup>3+</sup> ions (GSGG:Cr<sup>3+</sup>, Nd<sup>3+</sup>). Studies evaluating the maximum characteristics of GSGG:Cr<sup>3+</sup>, Nd<sup>3+</sup> crystals when used in powerful lasers are of practical interest. The dependence of the damage threshold on the region of laser-crystal interaction (dimensional dependence) and the influence of  $\gamma$ -radiation and thermal annealing on GSGG:Cr<sup>3+</sup>, Nd<sup>3+</sup> laser strength are examined in this work.

Single-mode and multimode Nd lasers ( $\lambda = 1.06 \mu$ ), working at half-power, with a pulse length of  $\tau = 10$  nsec, were used in the experiments. The laser was focused onto the area of the crystals being studied by a microscope and lenses, with caustic diameters of 6, 12, 60, 120, and 150  $\mu$ . The damage thresholds at small caustics ( $d_c = 6-60 \mu$ ) were determined using single-mode radiation, while at large caustics ( $d_c > 60 \mu$ ) multimode radiation was used. To determine the damage threshold, an intensity of radiation was used such that damage occurred with a probability of 0.5. The standard method of registering damage by spark and residual radiation was used. The crystal samples studied were cylindrical rods 5 mm in diameter and 20 mm long with polished faces.

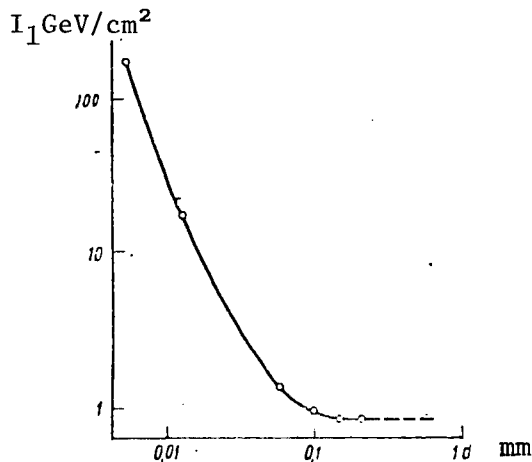


Fig. 1. Dependence of GSGG:Cr<sup>3+</sup>, Nd<sup>3+</sup> crystal damage threshold on caustic diameter

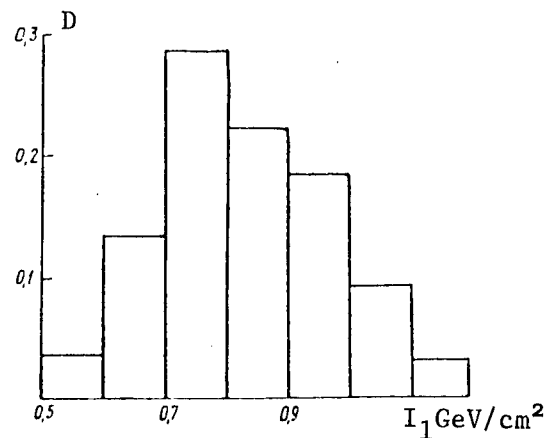


Fig. 2. Bar chart of the distribution of GSGG:Cr<sup>3+</sup>, Nd<sup>3+</sup> damage thresholds at  $d_c = 120 \mu$ . The value  $D$  reflects the relative number of points of the sample to which the damage thresholds in the given interval of intensities correspond.

The results of the damage threshold measurements at various caustic diameters are presented in Fig. 1. Here, we see that in the region of small caustics ( $d_c = 6-60 \mu$ ), the crystal's damage threshold varies by an order of 2. In our opinion, this is associated with the probabilistic way in which microdefects occur in the region of interaction. When the caustic diameter is further increased, the damage threshold decreases at a slower rate, and it tends to stabilize at  $d_c > 140 \mu$ . The threshold value  $I_t \approx 0.8 \text{ GeV/cm}^2$  represents the practically attainable radiation load on the GSGG:Cr<sup>3+</sup>, Nd<sup>3+</sup> crystals which were studied, with large areas of exposure. Significantly higher damage thresholds at small caustics suggest that it may be possible to raise the beam strength of GSGG:Cr<sup>3+</sup>, Nd<sup>3+</sup> crystals by perfecting their technology and reducing the concentration of microdefects.

The damage threshold values we achieved with the most common Nd lasers for a small caustic are given in the table. It is obvious that, under our conditions, the damage thresholds of the various laser materials exhibit virtually no difference within the bounds of measurement precision. With large volumes of interaction, the beam strength of GSGG:Cr<sup>3+</sup>, Nd<sup>3+</sup> crystals ( $0.8 \text{ GeV/cm}^2$ ) is approximately equal to that of YAG:Nd<sup>3+</sup> crystals ( $0.6 \text{ GeV/cm}^2$  [4]) and somewhat inferior to the patented GLS22 ( $2 \text{ GeV/cm}^2$  [5]). Earlier [4,5], the decisive role of microdefects, such as impurities in the laser strength of YAG and Nd:glass crystals, was noted. It is reasonable to assume that microdefects will significantly influence the damage processes of GSGG:Cr<sup>3+</sup>, Nd<sup>3+</sup> as well. This is indicated by the spread of damage

threshold statistics as well as by the dimensional dependence. A bar graph of the damage threshold distribution for  $\text{GSGG:Cr}^{3+}$ ,  $\text{Nd}^{3+}$  crystals with  $d_c = 120 \mu$  is shown in Fig. 2.

Heat treatment of  $\text{GSGG:Cr}^{3+}$ ,  $\text{Nd}^{3+}$  crystals at  $800^\circ\text{C}$  for 5 hours in air did not noticeably increase their laser strength.

The laser strength of a number of optical materials is decreased by  $\gamma$ -radiation; this is caused by the formation in them of radiation defects, such as color centers. To determine the effect of  $\gamma$ -radiation on the laser strength of  $\text{GSGG:Cr}^{3+}$ ,  $\text{Nd}^{3+}$  crystals, samples were subjected to  $\gamma$ -quanta in doses of 0.01-100 MR at room temperature. Induced absorption of  $\gamma$ -quanta was observed neither in the pumping region nor at the generation frequency. The laser damage thresholds coincide with the damage thresholds of unexposed samples to within a measurement error of  $\pm 10\%$ .

Thus, the promising  $\text{GSGG:Cr}^{3+}$ ,  $\text{Nd}^{3+}$  crystals have a high laser strength which is unaffected by  $\gamma$ -radiation up to doses of 0.1 GR.

Damage thresholds of active media  
(caustic diameter 6)

<u>Material</u>	<u>Damage threshold, TW/cm</u>
$\text{GSGG:Cr}^{3+}$ , $\text{Nd}^{3+}$	0.22
$\text{YAG:Nd}^{3+}$	0.2
GLS22	0.25

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Institute of General Physics  
AS USSR, Moscow

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ENERGETIC PROCESSES IN SOLID-STATE LASERS: FREE EMISSION MODE (NUMERICAL SIMULATION)

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 56, 1984 KVANTOVAYA ELEKTRONIKA

GRADOV, V.M., KOSTANTINOV, B.A., MAK, A.A., SKLIZKOV, G.V., FEDOTOV, S.I.  
and SHCHERBAKOV, A.A.

[Abstract] The authors have developed a method of numerical simulation applicable to all solid-state lasers for analysis and evaluation of their energy characteristics, based on integration of the processes occurring in all components of a laser device. The mathematical model includes the equations of radiation transfer in the geometrical optics approximation and the equations of kinetics for the active medium. For an analysis of the free emission mode, a four-level laser substance and second-degree surfaces bounding the various radiator regions are selected. The model is self-consistent, including the corresponding equations of energy balance with luminescence losses and thermal losses at nonradiative transitions taken into account. It was tested by comprehensive calculations of the energy balance for a  $\text{Nd}^{3+}$ -laser at several plasma temperatures, with several immersion media having different refractive indexes, with several resonator mirrors having different reflection coefficients, and with an active medium having a perfectly absorbing, diffusely reflecting, or specularly reflecting (polished) lateral surface. Besides the energy balance, calculations according to this model yield also the radial profile of emitted radiation flux density. An analysis of the results reveals that, in terms of maximum attainable efficiency, solid-state lasers fall into three types: 1) type-I lasers are "ideal luminous boilers;" 2) in type-II lasers, including those with hollow phototubes, the pumping radiation is strongly shielded by the discharge plasma; 3) type-III lasers, including close-packed and multitube ones, have their efficiency lowered by passive filtration over a wide region of the discharge-plasma radiation spectrum. A comparative evaluation of these three types covers all major factors differently influencing the efficiency of each. These factors are activator concentration, idle losses within the region of the pump's radiation spectrum, idle losses at the operating transition, superluminescence, stimulated filtration of ultraviolet radiation, absorption of radiation by the tube envelope and the immersion medium, gas pressure in the discharge, diameter of the discharge channel, and, most importantly, the reflection coefficient of the mirror. Separate

consideration is given to diffraction losses, which have been estimated for a high-efficiency (type-I) laser with a plane resonator. A comparison with experimental data indicates that the free emission efficiency also depends on the grade of glass and can be maximized by proper glass selection.

Figures 12; tables 6; references 43: 40 Russian, 3 Western.

[437-2415]

#### GAS-DYNAMIC LASERS ON CASCADE TRANSITION IN $\text{CO}_2$ , $\text{N}_2\text{O}$ , $\text{CS}_2$ MOLECULES MIXING WITH ACTIVE COMPONENT

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 87, 1984 KVANTOVAYA RADIOFIZIKA

BIRYUKOV, A.S., KARAKHANOVA, I.V., KONOPLEV, N.A. and SHCHEGLOV, V.A.

[Abstract] The energy characteristics of a gas-dynamic laser on cascade transitions in  $\text{CO}_2$  molecules mixing with excited nitrogen as donor gas in a supersonic stream are analyzed from the standpoint of performance optimization. Calculations are based on the mathematical model of instantaneous fast mixing, which includes the effect of turbulent diffusion and the requirement of small jet dimensions. As a specific example, mixing of  $\text{CO}_2$  molecules with a preheated  $\text{N}_2 + \text{H}_2\text{O}$  mixture expanding through a flat nozzle with a longitudinal profile  $F(x) = 1 + o \log(bx + 1)$  from  $x = 0$  to  $x = L$  and a uniform cross-section beyond  $x = L$  is considered. From the longitudinal temperature profile in the nozzle and the dependence of the maximum laser power, as well as of the corresponding number of laser pulses and pulse repetition rate and resonator length  $L$  on the temperature at the critical nozzle section, assuming a constant gas molecule concentration  $8.62 \cdot 10^{19} \text{ cm}^{-3}$  in the antechamber, the maximum attainable laser power and efficiency, along with the corresponding temperature at the critical nozzle section (1430 K), are determined. The results indicate the advantages of separate heating of the donor gas prior to mixing. Analogous results for  $\text{N}_2\text{O}$  and  $\text{CS}_2$  molecules indicate the feasibility of gas-dynamic lasers on radiative transitions in these triatomic molecules. Figures 12; references 25: 12 Russian, 6 Western.

[437-2415]



'LUMINOUS BOILER' AND PROBLEM OF RAISING EFFICIENCY OF SOLID-STATE LASERS  
WITH PHOTOTUBE PUMPING

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 106, 1984 KVANTOVAYA ELEKTRONIKA

BASOV, N.G., GERASIMOV, V.A., GRADOV, V.M., ZHILTSOV, V.I., ZVEREV, V.M.,  
KONSTANTINOV, B.A., KROMSKIY, G.I., MAK, A.A., SKLIZKOV, G.V., TEREYEV,  
Yu.I., FEDOTOV, S.I. and SHCHERBAKOV, A.A.

[Abstract] A "luminous boiler" is a laser pump with radiative heat transfer in the closed optical system. Its basic distinguishing characteristics derive from the unique energy balance and the high pumping efficiency. The three fundamental selection modes during multiple passage of radiation through the pumping system are active tuning through absorption of radiation by the discharge plasma, radiation within the idle region of the activator's spectrum (type I) or radiation within the operative region of the activator's spectrum (type II), passive tuning through absorption of radiation by passive optical components, such as mirror or filters, and activator tuning through absorption of radiation by the activator. Each selection mechanism is analyzed for the simplest case of pumps with inert-gas filler and thus an approximately uniform temperature distribution over the discharge volume, with negligible conductive heat transfer from plasma to tube walls, and with constant emittance of the plasma at fixed discharge temperature and pressure in the open phototube or in phototube with closed pumping system. The mathematical model for numerical evaluation of the energy characteristics in each mode, namely, individual losses and dependence of the efficiency on the electrical power for free emission and on the optical system parameters, is based on the approximation of discrete rays with application of the Monte Carlo method to refracting surfaces. A comparison with experimental data on discharge in xenon for a neodymium laser using GLS-24 glass indicates that the main requirements for approaching the "ideal luminous boiler" are minimum active and passive filtration of plasma radiation within the operative region of the activator's spectrum, maximum utilization of the activator's entire absorption spectrum, maximally amplified filtration of plasma radiation within the idle region of the activator's spectrum, and maximum attenuation of superluminescence effects. From this standpoint, the existing "Delfin," "Flora," "Shiva" laser thermonuclear fusion facilities are then evaluated, as well as the "Mikron" high-energy monopulse laser facility. Figures 12; references 43: 37 Russian, 6 Western.  
[437-2415]

## EFFECT OF STRAIN ANISOTROPY ON EMISSION CHARACTERISTICS OF GaInPAs/InP LASERS

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 107, 1984 KVANTOVAYA RADIOFIZIKA

YELISEYEV, P.G., SVERDLOV, V.N. and SHOKHUDZHAYEV, N., Optoelectronics  
Laboratory

[Abstract] The effect of uniaxial compression normal to the active plane of a GaInPAs/InP bilateral heterostructure and of the resulting strain anisotropy on the energy spectrum and of the energy characteristics of such an injection laser are analyzed for the purpose of determining the pressure sensitivity and explaining the variances in behavior. First, a relation is established between the coherence range and tetragonal distortion of the lattice by nonconformity dislocations in an epitaxial semiconductor layer of finite thickness. On this basis, changes in the temperature dependence of the threshold current and in the preferential radiation polarization are considered, as well as in the emission power-current characteristic and efficiency under varying external pressure and resulting strain anisotropy. For experiment verification, GaInPAs layers were grown on p-InP substrates by epitaxy from the liquid phase. Specimens with wide contact tabs and specimens with strip contacts were tested emitting pulses of 0.3  $\mu$ s duration at a repetition rate of 4 KHz at radiation wavelengths from 1.08 nm to 1.61 nm, after Fabry-Perot resonators had been built on. The emission spectrum was analyzed with an MDR-2 monochromator, and the energy characteristics over the 150-300 K temperature range were measured with an FDG-3 germanium photodiode receiver over the entire mechanically allowable pressure range. With regard to polarization, there were specimens emitting a TE-mode or a TM-mode over the entire pressure range and specimens switching from TE-mode to TM-mode emission at some critical pressure level. In calculating the pressure sensitivity of the emission efficiency, namely, the derivative of efficiency with respect to pressure, on the basis of those data, one assumes that the internal optical losses are most probably pressure dependent. The results indicate that mechanical stresses in these laser heterostructures can vary within the coherence range of the lattice, owing to technological variance of Ga and As concentrations. The threshold current is maximum and the differential efficiency is minimum at the pressure level or degree of anisotropy which corresponds to polarization switching. The stress dependence of also the emission efficiency distinguishes GaInPAs/InP lasers from AlGaAs/GaAs lasers. Figures 22; tables 4; references 24: 13 Russian, 11 Western.  
[437-2415]

# EFFICIENT QUASI-CONTINUOUS HIGH-PRESSURE NITROGEN LASER ON FIRST NEGATIVE SYSTEM

Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian  
Vol 42, No 1, 10 Jul 85 (manuscript received 27 May 85) pp 39-42

BASOV, N.G., ALEKSANDROV, A.Yu., DANILYCHEV, V.A., DOLGIKH, V.A.,  
KERIMOV, O.M., MYZNIKOV, Yu.F., RUDOY, I.G., SAMARIN, A.Yu. and SOROKA, A.M.,  
Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences

[Abstract] An efficient quasi-continuous laser on allowed transitions of the  $N_2^+$  ion in a high-pressure  $N_2$ -He active mixture is described, with electron-beam pumping sufficiently powerful for self-limiting of emission at the first negative system, very effective population of the  $B^2\Sigma_{uv=0}^+$  laser level

making B-X transitions particularly favorable. In addition to speed and selectivity of the "quenching" process, it is necessary to ensure that molecular ions formed by depopulation of  $N_2^+(X)$  particles do not absorb any of the laser radiation. Such an ion is  $N_2H^+$  formed in the  $N_2^+(X) + H_2 \rightarrow N_2H^+ + H$  process at a high rate of approximately  $2 \cdot 10^{-9} \text{ cm}^3/\text{s}$ . The power of spontaneous emission at the  $B^2\Sigma_{uv=0}^+ \rightarrow X^2\Sigma_{gv=1}^+$  transition (428 nm wavelength), measured as a function of the hydrogen pressure in a  $P_{He}:P_{N_2+H_2} = 6 \text{ atm}:4 \text{ torr}$  mixture with electron-beam pumping, was

found to drop by 15-20% at the hydrogen pressure of 2 torr ensuring the necessary rate of  $N_2^+(X)$  depopulation. Taking into account the attendant Penning ionization, these data yield a higher than  $10^{-11} \text{ cm}^3/\text{s}$  rate of  $B^2\Sigma_{uv=0}^+$  "quenching" by  $H_2$  molecules and thus a "quenching" of the upper level at least 100 times slower than "quenching" of the lower level. Experiments were performed with pumping by an electron beam of 200 keV energy and up to  $7 \text{ A/cm}^2$  current density in pulses of 0.7  $\mu\text{s}$  duration. The active region occupied a volume of  $1 \text{ dm}^3$ , the resonator was formed by two highly selective dielectric mirrors with an area of  $8 \times 3.5 \text{ cm}^2$  each and with transmission coefficients at the 428 nm wavelength  $T_1 \leq 0.1\%$  and  $T_2 \cong 1\%$ , respectively. The laser emission characteristics, namely, emission energy and efficiency as a function of pumping current density, were measured with the active mixture under a total pressure of 6 atm. At the hydrogen pressure of 2 torr, a nitrogen pressure of 4 torr was found to be optimum for most effective luminescence. Owing to the high pressure of the mixture in this experiment, emission was obtained near the "red edge" of the first negative system rather than at the P(7) line corresponding to maximum population of the upper laser state. This suggests that increasing the pressure of the buffer gas will increase the gain, which has been confirmed by raising the pressure to 10 atm. With aluminum-coated mirrors forming a nonselective resonator, emission was obtained only at the 0-0 band of B-X transition, in the ultraviolet region (391 nm wavelength), in pulses of 400 ns duration. The efficiency of quasi-continuous emission at both 0-0 and 0-1 bands of the first negative system reached 2% in each case. Figures 2; references 11: 9 Russian, 2 Western.

[556-2415]

## ENERGY STUDY OF A PICOSECOND DYE LASER WITH DISTRIBUTED FEEDBACK

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: FIZIKA in Russian Vol 20, No 4, Jul-Aug 85 (manuscript received 4 Jan 84) pp 230-233

AMBARYAN, A.Sh., MURADYAN, A.Zh., OGANESYAN, M.K., PAPAZYAN, T.A. and KHACHATRYAN, R.Zh., Scientific Research Institute of Physics of Condensed Media, Yerevan State University

[Abstract] Results are presented from studies of the variation in output energy parameters of a laser with distributed feedback based on an ethanol solution of rhodamine 6Zh as a function of pumping and of the statistical properties of the laser. The device uses a total internal reflection prism and is pumped by a PGS-1 with a wavelength of 0.53  $\mu\text{m}$ , energy about 20 mJ, pulse length about 40 ps, energy dispersion 20%, pulse length dispersion 24%. The variation in summary laser output energy as a function of picosecond pumping energy is diagramed. Excitation must occur outside the area of saturation, otherwise the relative contribution from the peak area of the pumping pulse is relatively smaller than the initial and final areas. This breaks down the proportionality of the population to the number of incident photons, and the pumping energy does not unambiguously determine the output generation energy. This is confirmed by an experimental study of the variation in output energy of each generated line as a function of picosecond exciting pulse length with constant exciting pulse energy. The parameter determining the output energy is found to be the pumping energy, while changes in fluctuation of exciter radiation within limits of 10% do not influence fluctuations in the output pulse. Figures 3; references 8: 6 Russian, 2 Western.  
[6508-88]

## A 2.12 MICROMETER No:YAG LASER

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 11, No 11, 12 Jul 85 (manuscript received 25 Dec 84) pp 682-685

ANTIPENKO, B.M., GLEBOV, A.S., KISELEVA, T.I. and PISMENNY, V.A.

[Abstract] This work expands the spectral capabilities of laser YAG materials by describing an effective No:YAG medium generating in the two micrometer wavelength area. In the medium studied,  $(\text{Y}_{0.89}\text{Th}_{0.10}\text{No}_{0.01})_3(\text{Al}_{0.99}\text{Cr}_{0.01})_5\text{O}_2$ , generation is excited easily at room temperature at a wavelength of 2.12 micrometers. An experiment was performed with an active element of 5 x 40 mm in an elliptical monoblock with silver coating and a type ISP-250 lamp. A comparatively low threshold of about 45 J and acceptable efficiency of about 0.5% were observed. Figures 2; references 8: 3 Russian, 5 Western.  
[533-6508]

IONIZATION DIAGNOSIS OF DENSITY OF MOLECULAR BEAMS BASED ON LASER-INDUCED ELECTRON TRANSFER

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 11, No 11, 12 Jul 85 (manuscript received 28 Jan 85) pp 645-648

BETEROV, I.M., FATEYEV, N.V. and CHEBOTAYEV, V.P., Institute of Heat Physics, Siberian Branch, USSR Academy of Sciences, Novosibirsk

[Abstract] A study is made of a new method of diagnosis of beams and streams of rarefied gas based on the use of collision ionization of molecules with atoms locally excited at the focus of a laser beam. The density of molecular beams can be diagnosed with good spatial resolution because the laser radiation in the visible or ultraviolet portion of the spectrum can be focused on a small spot on the order of one wavelength. An experimental demonstration of the method was undertaken in a system of Na + SF<sub>6</sub>. The absolute sensitivity of detection of molecules in the experiments was on the order of  $2 \cdot 10^8 \text{ cm}^{-3}$ . Simultaneous observation of photoionization from the excited 4d state allows determination of the relative concentration of atoms in this state excited during a pulse,  $10^{-4}$ - $10^{-3}$ , far from the limit with full saturation. Figures 2; references: 5 Russian. [533-6508]

UDC 621.378.325

EFFECTIVE MODES FOR GENERATING AND AMPLIFYING ULTRASHORT LIGHT PULSES IN RUBY AND YAG:Nd CRYSTALS

Moscow EFTEKTIVNYYE REZHIMY GENERATSII I USILENIYA ULTRAKOROTKIKH IMPULSOV SVETA V RUBINE I AIG:Nd in Russian 1984 pp 3-22

VARNAVSKIY, Oleg Petrovich

[Abstract] The coherent application of ultrashort (30-80 ps) light pulses in activated ruby and YAG:Nd crystals at low temperature is investigated. The possibility of employing this amplification mode to form high-power ultrashort pulses is evaluated. A number of operating modes of ruby and YAG:Nd mode-locked lasers are investigated, e.g., lasers with dense nonlinear absorbers. It is shown possible to realize energy-efficient lasing using a nonlinear absorber with low initial transmission. The basic requirements for the parameters of the active medium and absorber required for reliable generation of ultrashort pulses are formulated. The influence of superluminescence on such lasers is assessed and is shown to hinder the realization of optimal lasing modes in some cases. References 17: 14 Russian, 3 Western. [436-6900]

# INVESTIGATION OF INFLUENCE OF ANION IN POLYMETHINE DYE MOLECULE ON OUTPUT CHARACTERISTICS OF PASSIVE MODE-LOCKED LASER

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 29, No 5, 1985  
(manuscript received 31 Jan 84) pp 427-429

DEMCHUK, M.I., MIKHAYLOV, V.P., YUMASHEV, K.V. and AVDEYEVA, V.I.,  
Scientific Research Institute for Applied Physical Problems imeni  
A.N. Sevchenko

[Abstract] A detailed investigation is made of the way in which laser parameters are influenced by different anions in a polymethine dye molecule, using the example of dyes No 3955 and 1000 in different solvents. The spectral-luminescent characteristics of saturable absorbers and their parameters are analyzed; a criterion for selecting the components of the saturable absorber solution that determine the optimal mode of a passive mode-locked laser is determined on the basis of experimental findings. It is shown that the anion in the polymethine dye molecule used for passive mode-locking the laser has a strong influence on the relaxation time and absorption cross-section of the saturable absorber and, consequently, on the energy and duration of ultrashort pulses, the nature of the stretching of the pulses, and the spectral-luminescent characteristics of the solutions. References: 4 Russian.  
[442-6900]

UDC 621.373.8.038.825.4

# GAIN CONTOUR SPECTRUM OF INJECTION LASERS ON AlGaAs DIHETEROSTRUCTURE WITH WEAKLY DOPED ACTIVE REGION

Moscow KRATKIYE SOOBSHCHENIYA PO FIZIKE: SBORNIK in Russian No 3, Mar 85  
(manuscript received 1 Oct 84) pp 7-10

BESSONOV, Yu.L., MOROZOV, V.N., CHANG MIN THAI and SHIDLOVSKIY, V.R.

[Abstract] An experimental study was made for determining the gain spectrum of injection lasers on an AlGaAs planar heterostructure with a 5  $\mu\text{m}$  wide strip contact, by measuring the emission power in the resonator mode and at the adjacent dip in the superluminescence spectrum. The gain spectrum at the emission threshold was calculated from these data and compared with theoretical data pertaining to an active region doped to a hole concentration  $p = 10^{18} \text{ cm}^{-3}$ . The discrepancies are attributed to widening of the spectrum with attendant increase of the gain at the acceptor level as the impurity concentration increases, rather than to variance of the internal loss and of the optical limit not large enough to cause such a significant error. For narrowing the gain spectrum, therefore, it is preferable to use a weakly doped active region. Figures 2; tables 1; references 6: 5 Russian, 1 Western.  
[546-2415]

## EFFECT OF THRESHOLD CONDITIONS ON SPECTRAL AND NOISE CHARACTERISTICS OF INJECTION LASERS WITH NARROW STRIP CONTACT

Moscow KRATKIYE SOOBSHCHENIYA PO FIZIKE: SBORNIK in Russian No 3, Mar 85  
(manuscript received 1 Oct 84) pp 11-14

BESSONOV, Yu.L., BORODKIN, A.A., KURLENKOV, S.S., MOROZOV, V.N.,  
SAPOZHNIKOV, S.M., CHANG MIN THAI and SHIDLOVSKIY, V.R.

[Abstract] An experimental study of injection lasers on an AlGaAs dihetero-structure with a 5  $\mu\text{m}$  wide strip contact and with an acceptor concentration  $p = 5 \cdot 10^{16} \text{ cm}^{-3}$  in the active region was made for the purpose of determining the dependence of their spectral and noise characteristics in the continuous-wave single transverse mode without spontaneous intensity fluctuations on the threshold conditions. The power-current characteristics were measured, with the conduction current varied by changing the reflection coefficient  $R_1$  of one resonator mirror while leaving the reflection coefficient  $R_2 = 0.3$  of the other mirror constant. Partial transillumination of that first mirror was found to raise the threshold current level, while the increasing power of spontaneous emission was found to smoothen the power-current curve. The width of the radiation spectrum is, accordingly, determined by the coefficient of spontaneous emission and the curvature of the gain contour within the peak region. The results thus indicate that a higher threshold current of an injection laser in the steady emission mode leads to a wider spectrum, owing to an increased power of spontaneous emission and a decreased gain deficiency of lateral longitudinal modes. The relative spectral fluctuation density within the peak region does, in turn, depend on that width of the radiation spectrum. Figures 3; tables 1; references 8:  
4 Russian, 4 Western.  
[564-2415]

UDC 621.373.8

## TUNABLE LiF COLOR CENTER LASERS

Moscow PERESTRAIVAYEMYYE LAZERY NA TSENTRAKH OKRASKI V KRISTALLAKH LiF  
in Russian 1983 pp 3-27

MIROV, Sergey Borisovich

[Abstract] Laser media based on LiF crystals with color centers are created and investigated as the basis for reliable, efficient lasers that are tunable in the near-IR region of the spectra and that operate at room temperature with high peak power and high pulse repetition frequencies. Single- and two-stage selective photoconversion processes are observed and investigated in  $F_2^-$ ,  $F_2^+$ , and  $F_2^-$  color centers in an LiF crystal exposed to

monochromatic laser pumping. A method is implemented for obtaining lasing on the  $F_2^+$  color center in an LiF crystal that employs preliminary photo-ionization of the centers in the laser pumping channel. A tunable pulse laser employing the  $F_2$  color center in an LiF crystal with extended service life is developed. The use of LiF ( $F_2 \rightarrow F_2^+$ ) lasers in selected excitation spectroscopy of activated media is shown to be promising. Using selective laser excitation, inhomogeneous broadening of the  $F_2^+$  bands in an LiF crystal at 77 K is detected; the values of the homogeneous and inhomogeneous components of the absorption and luminescence spectra of  $F_2^+$  color center transitions in LiF crystals are estimated. References 15: 11 Russian, 4 Western.  
[440-6900]

UDC 585.376.2

# DEGRADATION OF GaAs/(Al,Ga)As HETEROSTRUCTURE LASERS MOUNTED ON HEAT SINK THROUGH HARD SOLDER

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 55, No 7, Jul 85  
(manuscript received 4 Jul 84) pp 1463-1465

ZHIZDYUK, T.B., ZHUKOV, N.D., KALINICHENKO, V.M., KUZMIN, A.N., RYABTSEV, G.I. and SOKOLOV, S.N., Institute of Physics, BSSR Academy of Sciences, Minsk

[Abstract] Injection lasers with bilateral GaAs/(Al,Ga)As heterostructure were tested after mounting on copper heat sinks through hard Pb-Sn solder, for a performance evaluation and for determining the suitability of these solders. The devices had been produced by liquid epitaxy, with a plane contact geometry, and mounted with their p-regions on copper. The solder with the 473 K melting point was used for this experiment, with the thickness of the solder film not exceeding 5  $\mu$ m. Tests were performed at room temperature (293 K) and at a higher temperature (343 K) in plain air. Measurements of the pumping current  $I_p$  as a function of time revealed an increase of the ratio  $I_p/I_{p0}$  by only 8.5-10% within 1000 h and by only 20-25% within 3000-5000 h at both temperatures, while an increase of this ratio by a factor of 6-7 at the higher temperature is known to occur with indium as solder material. This difference can be explained by the temperature dependence of mechanical stresses in the semiconductor crystal in each case. The results of the experiment confirm that the performance degradation is proportional to the mechanical stress up to the 30 MPa level, beyond which it increases at a much faster rate, and thus indicate that hard Pb-Sn solders are adequate for this particular application. The authors thank V.P. Gribkovskiy for helpful discussions. Figures 2; references 9: 4 Russian, 5 Western.  
[554-2415]



## GAS DYNAMIC LASERS UTILIZING GASIFICATION OF CARBON

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 16 Apr 84) pp 683-688

BIRYUKOV, A.S., MARCHENKO, V.M. and PROKHOROV, A.M., Institute of General Physics, USSR Academy of Sciences, Moscow

[Abstract] The performance of  $\text{CO}_2$  gas dynamic lasers is analyzed theoretically, such lasers operating either with corrected chemical composition of the combustion products or with a stream of donor gas produced by carbon gasification, or with both. Calculations are based on analysis of the respective reactions and their role in determining the energy characteristics. Typical numerical results are given applicable to lasers operating in fuel plants or in MHD electric power plants, one with endothermic gasification of carbon produced by combustion of benzene in stoichiometric air and one with exothermic gasification of preheated carbon by a stream of oxidizer. In each case, the reaction occurs with a large excess of carbon so that the chemical equilibrium shifts toward formation of CO and  $\text{H}_2$  molecules. The latter method is preferable from the energy standpoint, although the molar fraction of CO increases in an oxygen-rich oxidizer stream. Slowness of the  $\text{VV}'$  exchange between CO and  $\text{N}_2$  vibrations, as well as asymmetry of the  $\text{CO}_2$  mode, must be considered in optimization of the laser energy characteristics. A favorable feature is that the products of carbon gasification can blend with the stream of carbon dust. The authors thank S.A. Gridin for assistance in calculations. Figures 1; references 28: 19 Russian, 9 Western (2 in Russian translation).  
[456-2415]

## FEBRILE RESPONSE OF ELECTRONS IN SEMICONDUCTOR LASER TO ULTRASHORT LIGHT PULSE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 21, No 4, Apr 85 (manuscript received 19 Apr 84) pp 689-693

RIVLIN, L.A., All-Union Scientific Research Institute of Optical Physical Measurements, Moscow

[Abstract] The dynamic characteristics of semiconductor injection lasers are analyzed, taking into account not only the time constant of spontaneous radiative electron-hole recombination and the lifetime of photons in the resonator, but also the not necessarily momentary intraband relaxation processes. Calculation of the response to an ultrashort light pulse, based on a quasi-Fermi distribution with shift of Fermi quasi-levels and on changes

of electron concentration, as well as of total electron energy, reveal a febrile heating-cooling or cooling-heating of electrons and thus confirm the already known departure of the charge carrier temperature from the lattice temperature. The quantitative analysis of this phenomenon is necessarily particularized for a laser model with radiative transitions, but the rules of quasi-momentum selection between the floor of the conduction band with an exponential "tail" density of states and the ceiling of the valence band with an isolated group of levels are disregarded. Numerical estimates indicate that  $\partial T/\partial N$  can reach several degrees Kelvin per picojoule of light pulse energy in a semiconductor laser of typical dimensions. The author thanks S.P. Prokofyeva and A.F. Solodkov for evaluating the two integrals in the problem. Figures 4; references: 5 Russian. [456-2415]

UDC 621.373.826:537.56

# SELF-FOCUSING OF LASER RADIATION IN MOLECULAR GASES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 11 Oct 84) pp 708-712

OSIPOV, A.I., PANCHENKO, V.Ya. and FILIPPOV, A.A., Moscow State University imeni M.V. Lomonosov

[Abstract] Self-focusing of laser radiation triggered by nonequilibrium vibrational excitation of gas molecules is analyzed, considering that such an excitation of molecules increases their polarizability and thus also their refractive index. The latter is expressed in the form  $n = 1 + 2\pi N(\alpha_0 + \alpha_v)$  ( $N$  - molecule concentration,  $\alpha_v$  - vibrational component of molecular polarizability averaged over the corresponding molecule distribution,  $\alpha_0$  - initial polarizability prior to incidence of laser radiation). The equation for self-focusing is formulated in a quasi-optics approximation, namely, as a "parabolic" equation for the complex amplitude of the electric field, and assuming moderate vibrational temperatures of all modes so as to satisfy the conditions for harmonicity. The change of refractive index is determined from the equation for the margin of vibrational quanta. Numerical results have been obtained for a one-component gas such as  $SF_6$  with 15 vibrational modes, some of vibrational-rotational levels at a transition frequency close to that of  $\nu_3$ -mode vibrations being directly excitable by radiation from a  $CO_2$ -laser, as well as for several  $SF_6$ -He and  $CO_2$ - $N_2$  mixtures. Calculations were based on available experimental data and the Lambert-Saulter relation for the VT-relaxation time at moderate excitation levels. Figures 3; references 12: 10 Russian, 2 Western. [456-2415]

## RADIATION EMISSION BY PERYLENE VAPOR PUMPED BY LASER OVER BROAD RANGE OF SPECTRUM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 3 May 84) pp 719-723

BARKOVA, L.A., GRUZINSKIY, V.V., DANILOVA, V.I., DEGTYARENKO, K.M. and KOPYLOVA, T.N., Siberian Institute of Engineering Physics imeni V.D. Kuznetsov, Tomsk

[Abstract] In an experimental study, perylene vapor, pure and after stabilization with pentane, was transversely pumped by radiation from various lasers covering a broad range of the spectrum (KrF\* with  $\nu_{p1} = 40,160 \text{ cm}^{-1}$ , XeF\* with  $\nu_{p2} = 28,490 \text{ cm}^{-1}$ , 1,4-distyrene benzene in toluene with  $\nu_{p3} = 24,150 \text{ cm}^{-1}$ , POPOP in toluene with  $\nu_{p4} = 23,810 \text{ cm}^{-1}$ ), in pulses of 7 ns duration at a repetition rate of 1 Hz. The pumping power was focused on a 1 cm long and 0.05 cm wide strip so as to attain power densities of 30-57 MW/cm<sup>2</sup> at  $\nu_{p1}$ , 6-35 MW/cm<sup>2</sup> at  $\nu_{p2}$ , and approximately 1 MW/cm<sup>2</sup> at  $\nu_{p3}$  or  $\nu_{p4}$ . Measurements were made of the fluorescence absorption spectrum, the fluorescence quantum yield, and the fluorescence time, their dependence on the pumping frequency representing the margin of vibrational energy and on the ethylene pressure at various temperatures. Noteworthy was that the quantum yield remained approximately constant with changing excitation frequency and that the variability of the spectra increased with increasing margin of vibrational energy. Addition of pentane was found to shift the emission toward longer waves, with the spectral content remaining independent of the pumping frequency at any pentane concentration over the  $(0.66-2) \cdot 10^{21}$  molecules/cm<sup>3</sup> at 545-600 K temperatures. Addition of high-pressure stabilizing pentane was also found to lower the emission threshold and to make the emission pulse approach duplication of the pumping pulse. Figures 4; references 12: 10 Russian, 2 Western. [456-2415]

## ENERGY CHARACTERISTICS OF AUTONOMOUS CONTINUOUS-WAVE CHEMICAL CO-LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 22 May 84) pp 779-787

STEPANOV, A.A., SHCHEGLOV, V.A. and SHCHETINKINA, T.A., Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Increasing the efficiency of a continuous-wave chemical CO-laser is considered, a desirable feature of such a laser being its ability to

operate autonomously without external trigger. The three requisites for high efficiency are a high energy yield ( $-\Delta H = 85$  kcal/mol) and high rate ( $k \approx 5 \cdot 10^{-11}$  cm<sup>3</sup>/s at  $T = 500$  K) of the  $CS + O \rightarrow CO(v) + S$  reaction as excitation mechanism and a slow VT-relaxation. Particularly interesting developments have been realizations of such a laser with freely burning flames, first a  $CS_2-O_2-N_2$  flame and then a  $CS_2-O_2$  flame, followed by realization of a supersonic variant with thermal dissociation of  $CS_2$  and burning of  $C_2N_2$  in  $O_2$  or of  $H_2-CH_4$  in  $NF_3$ . The basic processes of vibrational kinetics in such lasers involve CO-CO VV-exchange and CO VT-relaxation. For analysis and evaluation, the fundamental equations of kinetics and corresponding gas dynamics are formulated on the basis of the ring model, with a cylindrical nozzle (approaching a plane one as its radius is increased) and radial flow in the resonator cavity. Calculations are made on the basis of specific numerical data pertaining to the combustible jet mixture  $CS:S:CS_2:N_2:HF$  and the oxidizer jet mixture  $O_2:He$ , their pressures and temperature, as well as to the array of alternating combustible and oxidizer nozzles. As a result are obtained the radial profile of small-signal gain on vibrational-rotational transitions, the emission spectrum, and the dependence of specific energy, chemical efficiency, and lasing zone width on the oxygen dilution ratio  $\beta_{He} : \beta_{O_2}$ , on the initial mixture temperature, and on the nozzle radius. These results indicate the feasibility of a continuous-wave chemical CO-laser operating at 20% chemical efficiency and delivering an energy of 300 J/g. Experimentally established favorable factors here are the possibility of reducing the heat losses in larger laser systems and the possibility of increasing the laser output power by injection of  $N_2O$  molecules into the  $O_2-He$  stream so as to increase the population inversion at the lower vibrational levels in CO as a consequence of CO- $N_2O$  VV'-exchange. Figures 5; tables 1; references 21: 10 Russian, 11 Western (3 in Russian translation). [456-2415]

UDC 621.373.826.038.824

# SPECTRAL CHARACTERISTICS OF RADIATION FROM CONTINUOUS-WAVE DYE LASER WITH GASEOUS ABSORBING INTRACAVITY MEDIUM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 5 Jun 84) pp 810-814

DANILEYKO, M.V., NEGRIYKO, A.M., UDOVITSKAYA, Ye.G., KHODAKOVSKIY, V.M. and YATSENKO, L.P., Institute of Physics, UkSSR Academy of Sciences, Kiev

[Abstract] Wideband dye lasers are examined, of particular concern being narrowing of the radiation spectrum and locking of the radiation frequency near intense intracavity absorption lines. These effects in a continuous-wave dye laser with a linear resonator are analyzed on the basis of the theoretical model in which the diffraction loss in the resonator depends

nonmonotonically on the focal length of the lens inside, and the minimum of this loss determines the frequency locking, as well as on the basis of experimental data with a gas-discharge tube as intracavity lens. A population of metastable levels in the absorbing gas nonuniformly distributed over the tube cross-section imparts lens-like properties to such a tube, a parabolic radial profile of a metastable level making the focal length of the lens proportional to the deviation of the radiation frequency from the center frequency of the absorptive transition. Analysis of frequency locking and resonator stability, both depending on the lens and three-mirror resonator geometry, with attendant calculation of the laser beam radius in the caustic region, as well as of both lower and upper limits of the stability region in the case of long-focus lenses without constraint on the focal length, reveals that frequency locking facilitates narrowing of the spectrum to just two or three modes in a dye laser with linear resonator. Experiments with solution of 6Zh rhodamine in ethylene glycol pumped by an argon laser were performed using two spherical mirrors and a Littrow prism as third mirror, also a monochromator, two Fabry-Perot interferometers, and a spectrograph for measurements. Tuning this dye laser over the 565-615 nm range of wavelengths by rotation of the prism confirmed the dependence of its radiation spectrum on the pumping power qualitatively according to theory and the essential role of the absorbing medium, this role not depending on the field intensity inside the resonator cavity. Figures 6; references 8: 3 Russian, 5 Western. [456-2415]

UDC 631.373.826.038.825.4

#### SCANNED AND CONTINUOUS-WAVE GaSb LASERS WITH LONGITUDINAL ELECTRON-BEAM PUMPING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 17 Apr 84) pp 845-848

BRAGINSKAYA, A.G., KOZLOVSKIY, V.I., KOLCHINA, G.P., LAVRUSHIN, B.M., NASIBOV, A.S. and REZNIKOV, P.V.

[Abstract] A study was made of GaSb lasers longitudinally pumped by a scanning or continuous "at a point" electron beam. As active medium, GaSb single crystals grown by the Czochralski method were used, some of them of them doped with either donor or acceptor impurity. Laser cells with  $12 \text{ cm}^2$  active surface area were formed, and an opaque silver mirror with a reflection coefficient of 0.98 was used for operation in the  $1.6 \text{ }\mu\text{m}$  wavelength band. Electron beams  $15 \text{ }\mu\text{m}$  in diameter with 50, 75, 100 keV energy and currents up to  $300 \text{ }\mu\text{A}$  were used for pumping at a scan rate of  $2 \cdot 10^5 \text{ cm/s}$ . Spectral characteristics were measured with an MDR-2 monochromator, emission power was measured with a germanium photodiode, and the radiation pattern was plotted by scanning that photoreceiver in the far field in the direction perpendicular to the electron beam scan. As a result, in addition to the radiation patterns and the emission spectra at various levels of the electron beam current, the power-current characteristics of the active medium at 80 K

and 300 K temperatures in both scanning and continuous modes were also obtained. The data reveal that the power peaks at some level of the electron beam current, this current becoming lower and the corresponding maximum power becoming higher as the pumping electron energy is increased. In the continuous mode, as the electron beam current was increased from 0 to 6  $\mu\text{A}$ , the wavelength of most intense emission and the temperature of the active region were found to increase linearly from 1.54  $\mu\text{m}$  to 1.66  $\mu\text{m}$  and from 80 K to 200 K, respectively. The power of a continuous-wave laser was maximum at the 1.6  $\mu\text{m}$  wavelength. Figures 5; tables 1; references: 7 Russian. [456-2415]

UDC 621.373.826.038.825.4

# EMISSION THRESHOLD AND BEAM DIVERGENCE OF SEMICONDUCTOR LASERS WITH LONGITUDINAL ELECTRON-BEAM PUMPING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 15 May 84) pp 848-850

BOGDANKEVICH, I.L., BOGDANKEVICH, O.V., DARZNEK, S.A., ZVEREV, M.M., TUMANOVA, P.A. and USHAKHIN, V.A., All-Union Scientific Research Center for Study of Surface and Vacuum Properties, Moscow

[Abstract] Multicell semiconductor lasers with longitudinal electron-beam pumping and without external mirror are analyzed theoretically for dependence of their emission threshold and beam divergence on the transverse dimension of the active region. Calculations for a plane-parallel semiconductor target with mirror coating on both sides, reflection coefficient  $R_1 = 1$  on the front side and  $R_2 = R_{\text{var}} < 1$  on the back side, are based on steady-state solutions to the wave equation for the field of a light wave inside such a resonator. The half-width of the symmetric radiation pattern is found to increase almost linearly with increasing diameter of the active region. The numerical solution for a ZnO crystal and a back mirror with  $R_2 = 0.93$  was verified experimentally, 0.2 mm thick wafers cut from ZnO single crystals being pumped by electron beams 5-10 mm in diameter with 200 keV energy and up to 300 A/cm<sup>2</sup> current density in pulses of 10 ns duration. The number of excited transverse modes is approximately, but quite accurately,  $K = 0.20 \left( \frac{\alpha - \beta}{\beta} \right)^{0.79} C^{0.86}$  ( $\alpha$  - power gain,  $\beta$  - coefficient of distributed losses,  $C = k R_0^2$ ,  $k$  - wave number in active medium with the frequency of longitudinal modes much higher than the frequency of transverse modes,  $R_0$  - radius of active region). The emission threshold depends on the parameter  $C$  and not on the Fresnel number, also on the distribution of the refractive index. The effect of nonuniformity of that distribution becomes negligible, however, when the beam divergence angle is larger than the radial range of that nonuniformity under conditions of pumping (the refractive index being equal to the square root of the dielectric constant). Figures 2; references: 8 Russian. [456-2415]

REFLEXIVE EFFECTS OF RADIATION IN RESONATOR OF CO<sub>2</sub>-LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 17 Jul 84) pp 868-871

GALUSHKIN, M.G., KOVALCHUK, L.V., RODIONOV, A.Yu., SEREGIN, A.M.,  
USTINOV, N.D. and CHEBURKIN, N.V.

[Abstract] A significant effect of radiation in the resonator of a CO<sub>2</sub>-laser, one which influences the space pattern of emitted radiation, is nonuniform distribution of the radiation intensity over the resonator volume. This nonuniformity produces a nonlinear optical nonhomogeneity in the active medium, inasmuch as the VT-relaxation rate of excited molecules depends on the intensity of emitted radiation, a likely consequence being a broader radiation pattern. This effect is analyzed here theoretically, taking into account diffraction by the resonator mirrors and variation of the laser radiation density along the stream of active gas mixture. Calculations are based on two wave equations, one for each of two fields with slowly varying amplitudes traveling in opposite directions through an unstable telescopic resonator, and corresponding three equations of gas dynamics. Numerical results have been obtained for a CO<sub>2</sub>:N<sub>2</sub>:He = 1:5:2 mixture and a discharge with  $jE\tau = 0.3 \text{ J/cm}^3$  ( $j$  - current density,  $E$  - electric field intensity,  $\tau = 15 \text{ } \mu\text{s}$  pulse duration). Some initial attenuation of the nonhomogeneity is attributable to a finite inertia of the thermal nonlinearity mechanism and to the transiency of gas dynamic perturbations. Further analysis and estimates reveal that transverse nonuniformity of the radiation intensity in an unstable resonator is caused principally by interference of opposing waves, especially when one has a plane front and one has a spherical front, while longitudinal nonuniformity is strongly attenuated by molecular diffusion and thus does not significantly influence the space pattern of resonator modes. The authors thank A.P. Napartovich for helpful discussion of the results. Figures 3; references 10: 7 Russian, 3 Western.  
[456-2415]

## INCREASING EFFICIENCY OF BEAM-PUMPED Xe-LASER BY MEANS OF MOLECULAR ADDITIVES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 30 Oct 84) pp 874-876

BUNKIN, F.V., DERZHIYEV, V.I., MESYATS, G.A., SKAKUN, V.S., TARASENKO, V.F.  
and YAKOVLENKO, S.I., Institute of General Physics, USSR Academy of  
Sciences, Moscow

[Abstract] An original experiment with atomic Xe-lasers was performed for establishing the feasibility of further increasing their already high

efficiency of the order of 1% by means of molecular additives. Four atomic mixtures and atomic pure xenon under usual pressure were modified with corresponding change of emission energy density as follows: Ar:Xe = 100:1 (2.5 atm, 2.3 mJ/cm<sup>3</sup>) to Ar:Xe:N<sub>2</sub> = 100:1:2.5 (2.5 atm, 5.5 mJ/cm<sup>3</sup>), Ar:Xe = 60:2.8 (2.5 atm, 0.7 mJ/cm<sup>3</sup>) to Ar:Xe:H<sub>2</sub> = 60:2.8:1 (2.5 atm, 1 mJ/cm<sup>3</sup>), Ar:Xe = 60:2.8 (2.5 atm, 0.7 mJ/cm<sup>3</sup>) to Ar:Xe:CO<sub>2</sub> = 60:2.8:1 (2.5 atm, 4 mJ/cm<sup>3</sup>), He:Xe = 75:3 (3 atm, 0.25 mJ/cm<sup>3</sup>) to He:Xe:CO<sub>2</sub> = 75:3:1 (3 atm, 0.7 mJ/cm<sup>3</sup>), Kr:Xe = 40:2 (2.5 atm, 0.1 mJ/cm<sup>3</sup>) to Kr:Xe:CO<sub>2</sub> = 40:2:1 (2.5 atm, 1.5 mJ/cm<sup>3</sup>), Xe (0.1 mJ/cm<sup>3</sup>) to Xe:CO<sub>2</sub> = 16:1 (1 mJ/cm<sup>3</sup>).<sup>2</sup> The results indicate that the molecular additives have produced a new spectral line at the  $\lambda = 2.03 \mu\text{m}$  wavelength, of intensity approximately equal to that of the  $\lambda = 2.65 \mu\text{m}$  line, the emission intensity being maximum at both these lines. A hypothetical explanation of the results is that pumping of 5d[3/2]<sub>0</sub> and [5/2]<sub>0</sub> states by a recombination flux with an appreciable dissociative component and emptying the lower 6p levels in collisions with heavy particles (drift of Xe into exciplex ArXe, HeXe, KrXe molecules) cause inversion in dense mixtures. Figures 2; tables 1; references 19: 12 Russian, 7 Western.  
[456-2415]

UDC 621.373.826.038.823

#### MEASUREMENT OF GAIN IN ULTRAVIOLET N<sub>2</sub> - LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 30 Jul 84) pp 882-883

PAPAKIN, V.F. and SONIN, A.Yu., Rostov State University imeni M.A. Suslov

[Abstract] Gain and discharge voltage in a transverse-excitation N<sub>2</sub>-laser operating in the pulse mode on the ultraviolet transition of the second positive system in an N<sub>2</sub>-molecule were measured by a method based on the relation  $\alpha = (1/L) \log \{ [(J - 1)/R][1 + (2c + K)^2/b + L] \}$  ( $J = P_2/P_1$ ,  $P_1$  and  $P_2$  - peak power at one end of the laser cell without mirror (after single pass) and with mirror (after double pass), respectively,  $L$  - length of laser cell,  $b$  - distance from slit diaphragm to laser cell,  $c$  - distance from laser cell to mirror,  $R$  - reflection coefficient of mirror. The peak power was determined from the levels of signals generated by an FEK-09 photocell and recorded by an S7-8 oscillograph. In the experiment with  $L = 0.26 \text{ m}$ ,  $b = c = 2.5 \text{ m}$ , and  $R = 0.04$  (quartz plate), the nitrogen pressure was varied over the 20-100 mm Hg range and the voltage was varied over the 18-28 kV range. The maximum gain  $\alpha$  was found to depend on the emission energy density  $\rho$  according to the relation  $(\alpha - \alpha_a)/(\alpha_o - \alpha_a) = 1/(1 + \rho/\rho_o)$  ( $\alpha_o = 24.4 \text{ m}^{-1}$  small-signal<sup>3</sup> gain in active medium,  $\alpha_a = 11.5 \text{ m}^{-1}$  loss coefficient,  $\rho_o = 2.4 \text{ J/m}^3$  saturation energy density. The loss coefficient depends only on divergence of the laser beam and dimensions of the laser cell. This method of measurement yields sufficient data for determining the optimum



reflection coefficient of the mirror  $R_{\text{opt}} = e^{2L(\sqrt{\alpha_o \alpha_a} - \alpha_a)}$  and for determining the dependence of the emission energy density  $\rho$  on the ratio  $E/p$  of electric field intensity to gas pressure  $\rho = \rho_* e^{K[(E/p) - (E/p)_*]}$  ( $\rho_* = 0.122 \text{ J/m}^3$  and  $(E/p)_* = 100 \text{ V/cm(mm Hg)}$  corresponding to the emission threshold,  $K$  - laser transition constant). Figures 2; references 6:  
 3 Russian, 3 Western.  
 [456-2415]

## NUCLEAR PHYSICS

### ENERGY ESTIMATES FOR COMPOUND HEATING OF THERMONUCLEAR TARGETS

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 114, 1984 KVANTOVAYA RADIOFIZIKA

AFANASYEV, Yu.V. and ISAKOV, V.A., Department of Theoretical Radiophysics

[Abstract] The energy of compound heating of a spherical thermonuclear target first by a laser beam and then by an ion beam is estimated in a feasibility study of inertial thermonuclear fusion involving compression of such a target to densities of the order of  $100 \text{ g/cm}^3$  with temperatures at its center of the order of 10 keV. In the simplest configuration, a homogeneous spherical charge of thermonuclear fuel, a deuterium+tritium mixture, is first compressed by a laser beam and then brought to the kindling point by an ion beam. The energy of such a compound heating is calculated as a function of initial radius, mass, and temperature. These calculations are based on the analytical solution to the corresponding system of two differential equations which describe the heating kinetics and the target scatter kinetics, respectively, assuming uniform heating of the target. Estimates pertaining to the feasibility of reaching the physical threshold of thermonuclear fusion reaction and the necessary supplemental ion pulse energy are obtained on this basis for a target with typical geometrical dimensions and physical properties. Preheating by a  $\text{CO}_2$ -laser beam and afterheating by an ion beam with either constant or variable energy is considered. In the first case, the laser pulse must be shaped so that its energy is efficiently converted into energy of fast electrons capable of heating the compressed target up. In the second case, the target is compressed with ablation by ions with an energy appropriately varying in time. Figures 1; references 11: 4 Russian, 7 Western.

[437-2415]

## NEUTRINO BEAMS IN MULTI-TeV ACCELERATORS

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
Preprint No 145, 1984 FIZIKA VYSOKIKH ENEGRIY I KOSMICHESKIKH LUCHEY

SALEYEV, V.A., TSAREV, V.A. and CHECHIN, V.A.

[Abstract] The distribution of neutrinos produced by fission of  $\pi$ -mesons and K-mesons is evaluated, also the distribution of equilibrium mesons in the attendant meson flux, with consideration of not only the meson generation-annihilation mechanism but especially the appreciable contribution of "direct" neutrinos produced by fission of charmed particles. The probability of muon generation in the substance in front of the neutrino detector is taken into account, as are the inclusive cross-section for generation of mesons and distortion of the scaling. The energy spectrum and the energy characteristics of direct neutrinos in the 3-30 TeV range, of particular interest here, are calculated analytically and estimated numerically. Figures 6; references 24: 10 Russian, 14 Western.  
[437-2415]

UDC 621.039.51.519

## POSSIBILITY OF DECREASING LIMITATIONS OF REACTIVITY WHEN WORKING WITH GASEOUS NEUTRON ABSORBERS

Alma-Ata IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR: SERIYA FIZIKO-MATEMATICHESKAYA in Russian No 6, Nov-Dec 85 (manuscript received 23 Mar 84) pp 60-62

ARINKIN, F.M., BATYRBKOV, G.A., BEKMYRZAYEVA, Z.B., GIZATULIN, Sh.Kh., SOBOLEV, Yu.A. and TALANOV, S.V., Institute of Nuclear Physics, Kazakh Academy of Sciences, Alma-Ata

[Abstract] A method has been suggested for improving the effectiveness of gas regulators without decreasing requirements for nuclear reasearch safety. The purpose of this work is to study the dynamics of the change in reactivity upon full or partial loss of seal in such a regulator. The experimental installation included a cylindrical chamber 62 mm in diameter and 1300 mm long made of stainless steel, wall thickness 3 mm. A 9 mm diameter pipe 1000 mm long with an electric valve was used to input and withdraw gas, with the pressure in the cylinder monitored by a high precision pressure sensor. The initial process, leakage of gas to normal atmospheric pressure, is found to depend essentially on the gauge pressure and reactivity of the operating unit. Loss of seal in the operating unit is found to result in a rapid jump in reactivity due to outflow of the gas under pressure, and long-term liberation of reactivity with complete disappearance of the absorbing medium over a period of time longer than that necessary for operation of the emergency protection equipment. Figures 2; references: 5 Russian.  
[119-6508]

## MEASUREMENTS OF NEUTRON FLUX ALLOWING DETERMINATION OF CERTAIN REACTOR CHARACTERISTICS

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 49, No 6, Dec 85  
(manuscript received 17 May 85) pp 1018-1022

PRILEPKO, A.I., IVANKOV, A.L. and ORLOVSKIY, D.G., Moscow Engineering-Physics Institute

[Abstract] If all characteristics of a reactor are known, the neutron flux density  $u$  is usually determined by measuring the density of the incident flux of neutrons on the surface of the reactor and the initial distribution of neutrons by points in space and velocities. Assuming that the source function  $F$  is unknown, additional measurements can be made to determine the pair of functions  $u, F$ , i.e., determine the sources of radiation. The question as to what should be measured in order to determine the pair  $u, F$  is the major difficulty in stating the inverse problem. Mathematical models are studied to determine the answer to the question. A plan is developed for determining the source function using methods from semigroup theory. References 8: 6 Russian, 2 Western.  
[118-6508]

UDC 621.039.58

## ANALYSIS OF RESULTS OF GAMMA-SPECTROMETRIC CONTROL OF RADIOACTIVE CORROSION PRODUCTS IN NITRINE COOLANT DURING WASHING OF REACTOR LOOP

Minsk VESTSI AKADEMII NAVUK BSSR: SERYYA FIZIKA-ENERGETYCHNYKH NAVUK  
in Russian No 4, Oct-Dec 85 (manuscript received 25 Sep 84) pp 19-24

NESTERENKO, V.B., ZHEMZHUROV, M.L., KATANAIEV, A.O., LEVADNYY, V.A.,  
POPLYKO, I.Ya. and RENICH, O.Z., Institute of Nuclear Power Engineering,  
Belorussian Academy of Sciences

[Abstract] A study is made of the possibility of hydrodynamic flushing of nuclear reactor coolant loops without the use of reagents, based on force and temperature effects of the coolant on the surface to be cleaned. Results are analyzed from gamma-spectrometric monitoring of radioactive corrosion products in a coolant during flushing of the loop channels of a reactor installation using gas and liquid phase nitrite. The reactor loop installation imitates the operation of a nuclear power plant loop with dissociating coolant and allows testing of several loop channels. The effectiveness of removal of radioactive contaminants was tested by continuous detection of the level of activity of radioactive corrosion products in the multiple forced circulation loop. Significant levels of deactivation were achieved. It was found that monitoring of radioactive corrosion product activity during flushing indicated that the temperature of washing significantly influenced

the effectiveness of the process. Under optimal conditions, practically complete removal of radioactive corrosion products can be achieved in a few tens of hours, leaving mechanically firmly bonded corrosion product deposits, which cannot be removed by flushing. Figures 1; references 13: 12 Russian, 1 Western.  
[6508-89]

UDC 621.039.54

MATHEMATICAL MODEL FOR CALCULATION OF STRENGTH AND TEMPERATURE CHARACTERISTICS OF A SPHERICAL FUEL ELEMENT IN A FAST NEUTRON REACTOR

Minsk VESTSI AKADEMII NAVUK BSSR: SERYYA FIZIKA-ENERGETYCHNYYH NAVUK  
in Russian No 4, Oct-Dec 85 (manuscript received 5 May 85) pp 15-18

NESTERENKO, V.B. and LI MAN KHO, Institute of Nuclear Genetics, Belorussian Academy of Sciences

[Abstract] A mathematical model is suggested for the design of a spherical fuel element with multilayer cover for use in a fast breeder reactor. The model is based on the following assumptions: The core is spherical and is surrounded by spherically symmetrical coatings; the elastic constants of the materials of the coatings are isotropic; the heat conductivity coefficients of the fuel and coating materials do not change upon bombardment; the distribution of temperature in the fuel element is considered steady and centrally symmetrical during the entire run of the reactor; the density of fission events is uniform. It is also assumed that no instantaneous plastic deformations occur in the fuel element. The classical methods of the mechanics of a deformed solid are used to obtain a differential equation for displacement with inelastic deformations (thermal expansion, radiation swelling, and creep). The problem is reduced to solution of an equation for displacement of points in the multilayer sphere.  
References 5: 4 Russian, 1 Western.  
[6508-89]

# EXPERIMENTAL INVESTIGATION OF HEATING AND COMPRESSION OF HIGH-ASPECT THERMONUCLEAR TARGETS ON DELFIN-1 INSTALLATION

Moscow EKSPERIMENTALNYYE ISSLEDOVANIYA NAGREVA I SZHATIYA VYSOKOASPEKTYNKH TERMOYADERNYKH MISHENEY NA USTANOVKE "DELFIN-1" in Russian 1983 pp 3-20

KALASHNIKOV, Mikhail Petrovich

[Abstract] The compression of high-aspect thermonuclear targets is investigated experimentally in the "compressed shell" mode at the (0.3-0.5) kJ absorbed laser energy level. Methods are developed and implemented on the Delfin-1 installation for forming high-contrast laser radiation, and monitoring the synchronization of the heating laser beams, that ensure good space-time homogeneity of irradiation of the target. X-ray methods are developed for investigating the compression dynamics and stability of shell targets. In compressing shell targets with aspect ratios of 100-250 in the "compressed shell" mode, yields of thermonuclear neutrons comprising  $10^6$ - $10^7$  neutrons per burst are recorded for compressed shell temperatures approximately 1-2 KeV. Filamentation of the plasma corona of the spherical targets is observed experimentally in the X-ray region of the radiation spectrum of the plasma, indicating the occurrence of hydrodynamic instabilities in the plasma that result in loss of compression stability. References 11: 9 Russian, 2 Western. [440-6900]

UDC 539.16

## CORRELATIONAL COULOMB ENERGY OF MIRROR NUCLEI AND THEIR MASS DIFFERENCE

Alma-Ata IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR in Russian No 4 (125), Jul-Aug 85 (manuscript received 30 May 84) pp 49-53

SHAGINYAN, V.R., Leningrad Institute of Nuclear Physics, Leningrad

[Abstract] The mass difference of mirror nuclei is calculated analytically in terms of residual nucleon-nucleon interaction, taking into account Coulomb interaction and its effect on the bond energy as well as single-particle levels in the first order with respect to  $e^2 k_F / T_F$  ( $e$  - charge of and electron,  $k_F, T_F$  - wave vector and kinetic energy of a nucleon on the Fermi surface. Coulomb interaction energy is expressed first as half an integral in which the ground-state potential appears with nucleon generation and annihilation, as well as Coulomb interaction operators, then with the particle-hole propagator introduced in the Hartree-Fock transient approximation. This energy consists of two parts, correlation and exchange, appearing with opposite signs rather than with the same sign as originally stipulated. There is no real contradiction here, however, since the correlation energy of a nuclear substance and of a finite nucleus is

determined, respectively, by the isovectorial component  $f' \approx 0$  and the isoscalar component  $f < 0$  of residual interaction. The two components are close in magnitude and partially compensate each other in a finite nucleus. The density dependence of the correlational Coulomb energy and the mass difference of  $^{15}\text{O}-^{15}\text{N}$ ,  $^{17}\text{F}-^{17}\text{O}$ ,  $^{17}\text{F}^*-^{17}\text{O}^*$ ,  $^{39}\text{Ca}-^{39}\text{K}$ ,  $^{41}\text{Sc}-^{41}\text{Ca}$ ,  $^{41}\text{Sc}^*-^{41}\text{Ca}$  mirror nuclei calculated on this basis agree closely with experimental data. Figures 1; tables 1; references 10: 2 Russian, 8 Western.  
[38-2415]

UDC 537.534

#### NONLINEAR PHENOMENA DURING TRANSPORT OF HIGH-POWER BEAM OF SMALL ION TO TARGET

Moscow FIZIKA PLAZMY in Russian Vol 11, No 7, Jul 85 (manuscript received 22 Nov 84 after revision) pp 802-809

KINGSEN, A.S., MOKHOV, Yu.V. and CHUKBAR, K.V., Institute of Atomic Energy imeni I.V. Kurchatov

[Abstract] The combined interaction of the electron beam and the plasma corona in an inertial ion-controlled thermonuclear fusion scheme is examined. It is shown that a mode favorable for ion-controlled thermonuclear fusion can be achieved by allowing for the strong nonequilibrium of the system and the nonlinear processes of current. The occurrence of anomalous resistance, attenuation of the reverse current, and the resulting magnetic field generation, which sometimes lead to beam inversion in the intrinsic magnetic field and hazardous preheating of the target, are investigated. Steep density gradients are recommended in order to convert the ion-sound instability to the mode investigated, i.e., the plasma channel of the beam must not contact the target. This is suggested as a less expensive way to avoid preheating and beam inversion. References 15: 13 Russian, 2 Western.  
[532-6900]

UDC 533.95

#### SIMPLE MODEL OF HEATING AND COMPRESSION OF SPHERICAL SHELL TARGETS BY INTENSE LASER RADIATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 31 May 84) pp 851-854

ANDREYEV, A.A. and SOLOVYEV, N.A.

[Abstract] Heating and compression of a spherical shell containing deuterium-tritium gas by laser radiation is treated as a combination of two

problems, the first one being absorption of laser energy by the "corona" with subsequent conversion of this energy into hydrodynamic motion of the target and the second one being formation of a compressed hot target core. The second problem is considered here, concurrent action of ablative pressure and a traveling heat wave being described by the conventional system of three equations. This system is solved on the basis of a known semiempirical relation for the ablative pressure under intense laser radiation as function of heat wave and sound wave velocities in the target material, these velocities being proportional both to the one-third power of the thermal flux density and, respectively, to the inverse four-thirds power and to the two-thirds power of the laser wavelength. The system of equations is first reduced to dimensionless form and simplified, then solved for the appropriate initial and boundary conditions in the three successive stages of the process: acceleration of the shell under dominant ablative pressure - free motion of the shell at zero ablative pressure - deceleration of the shell under deuterium-tritium gas counterpressure. An approximate solution is obtained first, assuming no energy transfer from gas to shell, whereupon this energy transfer is included for calculating the gas compression ratio and temperature as well as its neutron yield as functions of the shell wall thickness and of the shell mass to gas mass ratio. The results agree closely with the results of calculations according to the computer programs "Sfera" and "Zarya," as well as with available experimental data. Figures 3; references 14: 9 Russian, 5 Western. [456-2415]

UDC 621.378.9

#### THERMAL STABILITY OF CRYOGENIC TARGETS UNDER CONDITIONS OF LASER EXPERIMENT

Moscow KRATKIYE SOOBSHCHENIYA PO FIZIKE: SBORNIK in Russian No 3, Mar 85 (manuscript received 10 Dec 84) pp 38-41

KORESHEVA, Ye.R. and NIKITENKO, A.I.

[Abstract] The characteristics of cryogenic fuel layers, deuterium-tritium mixtures, in thermonuclear targets for fusion by laser are analyzed in terms of depthwise and surface homogeneity under conditions of heating. The two possible causes of surface breakdown in a symmetric temperature field are considered, namely, buildup of local inhomogeneities on the surface and excessive pressure of the gaseous phase at the center of the target. The ratio of gas mass to total fuel mass is selected as criterion of thermal stability and theoretical limits defining its permissible range are established for cryogenic fuel inside glass or polyethylene shells. Experimental verification involving compression of targets by laser beams under vacuum has revealed only a negligible heat transfer through the gaseous layer and only a thin surface layer of the solid target absorbing the incident radiation, assuming that all the energy of  $\beta$ -fission averaged over the spectrum converts into heat. Measurements have also yielded the



heating time to reach the breakdown temperature, with a Fourier number  $N_{Fo} \gg 1$  for all targets, considering that formation of local inhomogeneities at absolute temperatures higher than halfway to the melting point proceeds slower than heating to the breakdown point. Background radiation from laser and amplifiers being an important factor influencing the breakdown of a target, the thermal stability of the latter can be increased by inserting high thermal resistances between stages of the laser-amplifier structure and by adding a blanket. Crystal growth within the deuterium-tritium layer, leading to breakdown of the target, must be avoided. The authors thank A.I. Isakov and Yu.A. Merkulyev for helpful discussions and support and S.M. Tolokonnikov for assistance. Figures 1; tables 1; references 6: 5 Russian, 1 Western.  
[564-2415]

UDC 539.12.04

#### A METHOD FOR CALCULATING THE BRAKING SECTION OF NUCLEAR PARTICLES BY MATTER

Moscow ATOMNAYA ENERGIYA in Russian Vol 58, No 4, Apr 85 (manuscript received 15 Mar 84) pp 270-271

VOLKOV, V.F. and GERASIMOV, S.A.

[Abstract] A statistical model is proposed for atoms with a large number of electron states in order to calculate the passage of fast protons, alpha-particles, and atomic nuclei through matter and the concomitant energy loss caused primarily by ionization braking. The model assumes that the number of energy states of the electron gas is high enough for the discrete energy spectrum of the electron to be replaced by continuous ones. Theoretical calculations of  $dT/dx$  for atoms of Ar and Kr targets agree well with the experimental findings, confirming the validity of the model of ionization braking of nuclear particles by matter. The model can be used to solve a number of problems involved in studying ionization braking of heavy charged particles. References 10: 6 Russian, 6 Western.  
[419-6900]

PHOTOFISSION YIELD OF  $^{242}\text{Pu}$ 

Moscow ATOMNAYA ENERGIYA in Russian Vol 58, No 4, Apr 85 (manuscript received 25 Jun 84) pp 275-277

VO DAK BANG, ZAMYATININ, Yu.S., CHAN DYK TKHIYEP, CHAN DAY NGIYEP,  
FAN TKHU KHYONG, LE TKHI KAT TYONG

[Abstract] The post-neutron photofission yields of  $^{242}\text{Pu}$  by brehmstrahlung of electrons with energy of  $18.1 \pm 0.2$  MeV and  $20.7 \pm 0.3$  MeV, as well as the parameters of the distribution of the masses of the fragments, are determined. A target consisting of  $3 \pm 0.3$  mg of plutonium dioxide enriched to 94.7%  $^{242}\text{Pu}$  was employed. The fragments exiting from the layer were captured, and the unseparated mixture of fission products was subjected to gamma-spectrometry. The relative yields were calculated by the Rich 1 program running on a CDC-6500 computer. The peak/valley ratio obtained agrees well with that parameter as cited elsewhere. The total photofission yield of  $^{242}\text{Pu}$  by brehmstrahlung with boundary energy of 18.1 MeV and 20.7 MeV is tabulated for mass numbers ranging from 85 to 153. References 18: 8 Russian, 10 Western.  
[419-6900]

## LASER SOURCE OF POLARIZED PROTONS AND HYDROGEN IONS

Moscow PISMA V ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 42, No 1, 10 Jul 85 (manuscript received 5 Apr 85) pp 6-9

ZELENSKIY, A.N., KOKHANOVSKIY, S.A., LOBASHEV, V.M. and POLUSHKIN, V.G.,  
Institute of Nuclear Research, USSR Academy of Sciences

[Abstract] A novel source of polarized protons has been developed in which protons capture polarized electrons, after laser radiation has optically oriented the electron spin of atoms in a gaseous overcharge target. Protons from a generator pass through a gaseous neutralizing target, from which they emerge as a beam of hydrogen atoms. The latter is injected into a solenoid around an ionizing chamber with helium and a sodium target behind it. Protons generated in the ionizer are retarded by an electric field with a 1 kV potential, which eliminates the nonpolarized component, and then again neutralized in the sodium target while they capture polarized electrons. The thus polarized protons pass between two deflecting plates which remove residual ions from the beam, then through another chamber with helium for reionization, and through a deflecting magnet. The polarization of protons leaving this magnet is measured with a polarimeter which contains another sodium target where the protons are overcharged into metastable states. Their spin distribution is determined from the count-rate difference in a Lyman-alpha detector after their passage through a "spin filter" solenoid. Experimental measurements made on sodium atoms

have yielded the thickness of a highly polarized sodium target and thus the efficiency of polarized-electron capture, from which then also the efficiency of proton polarization could be determined. Record high polarized-proton currents have been obtained with this source, despite losses during beam extraction, namely, 1 mA with  $(65\pm3)\%$  polarization and 1.4 mA with 45% polarization when a retarding system was used, or 3.5 mA with 30% polarization when segregation according to energy was omitted. A current of polarized hydrogen ions as high as 60 mA can be obtained by replacing helium with xenon in the ionizer. The source operates in the pulse mode with a repetition rate of 1 kHz and produces polarized-proton current pulses of 20  $\mu$ s duration when a dye laser with optical pumping is used for orientation of atoms, the duration of those current pulses being determined by the duration of the laser pulses. The authors thank G.V. Roslyakov (Institute of Nuclear Physics, Siberian Department, USSR Academy of Sciences) and V.P. Nizhegorodtsev (Institute of High-Energy Physics, Serpukhov) for suggesting how to form a high-intensity beam of neutral atoms, D.P. Vinogradov for building the most intricate components of the proton source and the laser system, A.I. Berlev for designing the polarimeter electronics, M.A. Prokhvatilov for his major effort in automating the polarization measurements, and K.N. Vishnevskiy for assisting with the measurements. Figures 3; references 12: 8 Russian, 4 Western.

[556-2415]

## OPTICS AND SPECTROSCOPY

### DEPENDENCE OF SPECTRUM OF NITROGEN-LIKE IONS ON ELECTRON CONCENTRATION IN LASER PLASMA

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 204, 1984

BUNYAKOVA, M.Yu., VIKTOROV, D.S., PEREGUDOV, G.V. and RAGOZIN, Ye.N.,  
Spectroscopy Laboratory

[Abstract] The population of levels in  $2s^2 2p^3$ ,  $2s 2p^4$ ,  $2p^5$  configurations of nitrogen-like S X, Ar XII, Ca XIV, Ti XVI, Cr XVIII, Fe XX, Ni XXII ions was calculated over wide ranges of temperature and density, assuming a Gaussian radial profile of electron concentrations, whereupon the dependence of their spectra within the 80-130 Å range of the vacuum-ultraviolet region on the electron concentration was measured. The energy, as well as the probabilities of electric-dipole and radiative transitions, were determined according to the theory of  $1/Z$  perturbations ( $Z$  - spectroscopic symbol of ions) in its first-third orders for electrostatic interaction, with the intermediate binding structure in the LS-basis and with the relativistic correction in the  $O(\alpha^{-1})$  Breit-Pauli approximation ( $\alpha^{-1} = 137,036$ ). The system of equations for describing the populations of levels 1-5, including four equations of balance and the normalization constraint  $\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 + \alpha_5 = 1$ , was solved on an RDR-II/70 computer. The authors thank U.I. Safronova for supplying data on the nitrogen-like sequence and for advice on calculating the probabilities of radiative transitions, also Ye.A. Yukov for helpful discussions. Figures 5; tables 4; references 20: 16 Russian, 4 Western.  
[437-2415]

### REFRACTION IN PLASMA AND LASER RESONATORS FOR VACUUM ULTRAVIOLET REGION OF SPECTRUM

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA in  
Russian Preprint No 102, 1984 KVANTOVAYA RADIOFIZIKA

CHIRKOV, V.A., Spectroscopy Laboratory

[Abstract] Refraction in a plasma is analyzed in the geometrical optics approximation with the appropriate boundary conditions, specifically

refraction of radiation in the vacuum-ultraviolet region of the spectrum with wavelengths shorter than 1000 Å. The corresponding vector differential equation for the ray trajectory curvature in terms of the Hamilton operator is solved first generally, then for refraction by a normal profile  $N_e(x) = N_{e,0}x_0/x$  and a transverse profile  $N_e(y) = N_{e,0}(1 - y^2/y_0^2)$  of electron concentration with the range of  $t_0^x = z_0\gamma/x_0 \leq 1$  ( $\gamma$  - sliding angle at  $x \rightarrow \infty$  from the irradiation target,  $z$  - longitudinal coordinate along the axis of plasma jet dispersal) being of particular interest. The waveguide mode of propagation through a "well" in the transverse concentration profile is examined for feasibility of positive feedback. Various resonator configurations on this basis are subsequently evaluated, a spherical one appearing to be preferable to a plane or plano-spherical one on account of greater effectiveness for refracted radiation. The author thanks G.V. Peregudov and I.I. Sobelman for stimulation, Ye.P. Orlov, Ye.N. Ragozin, V.N. Shlyaptsev, and Ye.A. Yukov for helpful discussions. Figures 6; tables 3; references 51: 32 Russian, 19 Western (1 in Russian translation).  
[437-2415]

#### USE OF HOLOGRAPHIC REFLECTING DIFFRACTION GRATINGS FOR DIAGNOSIS OF LASER PLASMA DURING SPHERICAL HEATING OF THERMONUCLEAR TARGETS

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 90, 1984

BASOV, N.G., ALEKSANDROVA, I.V., DANILOV, A.Ye., KALASHNIKOV, M.P., MIKHAYLOV, Yu.A., SKLIZKOV, G.V. and FEDOTOV, S.I., Laser-Plasma Laboratory JUNGE, K., BRUNNER, W., GUETER, R. and KORN, H., Central Institute of Optics and Spectroscopy, GDR Academy of Sciences, Berlin

[Abstract] Holographic reflecting diffraction gratings are considered for harmonic analysis of emission in laser plasmas. The essential requirements are high-luminosity diffraction spectrograms with high spectral space-time resolution. The relevant optical characteristics of such gratings, namely, scattering and aberrations, are calculated from the corresponding equations of geometrical and physical optics. A comparison of theoretical results with experimental data on spherically symmetric heating and compression of a thermonuclear target indicates the feasibility of producing such diffraction gratings and using them for plasma diagnosis with the same measuring and recording apparatus over the x-ray region and the vacuum-ultraviolet region of the spectrum. Experiments were performed with the "Delfin-1" laser facility. Plano-concave gratings 50 x 50 mm<sup>2</sup> large with 1500 lines/mm and an aperture ratio of 0.5 were used for probing both fundamental-frequency and second-harmonic emission. Scattering was found to expand the spot to 3-4 times its initial radius at both frequencies. The experimental results are interpreted in terms of emission from a subcritical-density plasma, with the corresponding equations of electron ballistics and electromagnetic wave propagation. Figures 5; references 15: 8 Russian, 2 East German, 5 Western.  
[437-2415]

# SEMITRANSSPARENT MULTILAYER MIRRORS FOR X-RADIATION

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No68, 1984

VINOGRADOV, A.V. and KOZHEVNIKOV, I.V.

[Abstract] Periodic multilayer structures are considered for use as mirrors with either high reflection coefficient  $R$  or high transmission coefficient  $T$ . The theoretical feasibility is established on the basis of the corresponding wave equation  $\frac{d^2 E}{dz^2} + (\frac{\omega}{c})^2 [\epsilon(z) - \sin^2 \theta] E = 0$  ( $E, \omega, \theta$  - electric field,

frequency, incidence angle of plane incident wave polarized in the plane of incidence;  $\epsilon_1 \neq \epsilon_2 \rightarrow 1$  - dielectric permittivity of alternating layers for vacuum ultraviolet and soft x-radiation), which is solved with the aid of Fourier series expansion. The solution yields both reflection and transmission coefficients, as well as their dispersion characteristics, all depending on the incidence angle as well as on the number of layer pairs, on the structural period, and on the fraction of  $\epsilon_1$ -material in a period.

An analysis of the results indicates the feasibility of attaining a given ratio  $\frac{T}{R} = k$  and maximizing each coefficient with the other minimized or ideally reduced to zero at the same time. The maximum reflection coefficient is found to be independent of the incidence angle for an S-polarized incident wave. Figures 5; references 7: 4 Russian, 3 Western.  
[437-2415]

UDC 535.36

POLARIZATION OF RADIATION SCATTERED BY A SPHERICAL VOLUME OF A DISPERSED MEDIUM

Minsk VESTSI AKADEMII NAVUK BSSR: SERIYA FIZIKA-MATEMATYCHNYKH NAVUK in Russian No 6, Nov-Dec 85 (manuscript received 27 Feb 85) pp 71-74

IVANOV, A.P., GAVRILOVICH, A.B. and BORISEVICH, M.N., Institute of Physics, Belorussian Academy of Sciences

[Abstract] Existing methods of studying processes of scattering in such objects as storm clouds and dust clouds in space are primarily related to the energy characteristics of the departing radiation. However, the polarization of the radiation is also important. The method used for experimental modeling in this work allows comparatively simple study of the polarization properties of dispersed objects of various geometries. The model method assumes that a spherical volume of the substance being studied is struck by a parallel beam of radiation. The distribution of polarization over the surface of the object is also studied. Figures 3; references 11: 10 Russian, 1 Western.  
[6508-106]

UDC 537.533.34

COLLIMATION OF CHARGED-PARTICLE BEAM IN SPHERICAL AND CYLINDRICAL ELECTROSTATIC MIRRORS

Alma-Ata IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR in Russian No 4 (125), Jul-Aug 85 (manuscript received 19 Sep 84) pp 7-16

ZASHKVARA, V.V., YURCHAK, L.S., SAULEBEKOV, A.O. and VERMENICHEV, B.M., Institute of Nuclear Physics, KaSSR Academy of Sciences, Alma-Ata

[Abstract] Spherical and cylindrical electrostatic mirrors are considered for collimation of charged-particle beams. The design and performance analysis of such collimators is based on geometrical relations which yield the conditions for first-order and second-order collimation in the form, respectively, of first-order and second-order differential equations. The basic version is a single spherical electrostatic mirror, which can be

combined with cylindrical ones. The second version is a spherical mirror with a cylindrical mirror behind it, and the third version is a spherical mirror between two cylindrical ones. Complete sets of numerical data are given for such collimators mounted and operating at various angles to the axis of symmetry. Figures 2; tables 2; references: 6 Russian.  
[38-2415]

UDC 537.533.3

# TRANSIT TIME FOR CHARGED PARTICLES IN ELECTRONIC MIRRORS WITH DIRECT OPTICAL COUPLING

Alma-Ata IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR in Russian No 4 (125),  
Jul-Aug 85 (manuscript received 13 Jan 84) pp 66-73

DAUMENOV, T.D., SAPARGALIYEV, A.A. and YAKUSHEV, Ye.M., Kazakh State University imeni S.M. Kirov, Alma-Ata

[Abstract] Since space-time focusing of narrow charged-particle beams in an axisymmetric electrostatic field is possible only when that field constitutes an electronic mirror, such a mirror having only two conjugate planes of Gaussian images with time focusing of particles with respect to energy realizable in each, the more general case of stationary electrical and magnetic fields with a common straight axis combining to form an electronic mirror is considered next. After an appropriate change of variables, the corresponding transformed Lagrangian function is expanded into a power series in small coordinates, assuming also a small total energy of a charged particle. Solution of the differential equation of electron ballistics, which in this formulation splits into two equations, yields the transit time for a charged particle between two fixed surfaces. This transit time as a function of the axial coordinate is expanded into an infinite series  $t(z) = t_{(0)}(z) + \epsilon T_{1\epsilon}(z) + T_{(2)}(z) + \dots$ , whereupon

$T_{1\epsilon} = 0$  is established as the condition for first-order focusing of the transit time  $\left. \frac{\partial t}{\partial \epsilon} \right|_{\epsilon=0}$ . This is attainable merely by placing the source and the receiver on both sides of and at equal distances from the  $z - z_{T_1}$  plane.

The second-order chromatic transient aberration characterized by  $T_{2\epsilon}$  and the geometric transient aberrations characterized by  $T_{n1}, \dots, T_{n7}$  can then also be calculated. For practical applications, the results of this analysis are extended to systems with rotational symmetry in either Cartesian or cylindrical systems of coordinates. References: 2 Russian.  
[38-2415]



HOLOGRAPHIC SUBTRACTION OF IMAGES ON BASIS OF RECORDING AND SPACE FILTRATION  
IN FOURIER PLANE

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 55, No 7, Jul 85  
(manuscript received 16 Apr 84) pp 1329-1337

KLIMENKO, I.S. and MALOV, S.N., Moscow Institute of Engineering Physics,  
Dolgoprudnyy (Moscow Oblast)

[Abstract] Holographic subtraction of images by recording and processing in a Fourier plane is considered, an advantage of the Fourier plane being that it coincides with the plane of the hologram and space filtration of a diffusely scattered small-aperture field can be replaced with illumination by a small-aperture laser beam. An analysis of the process reveals formation of a regular interference pattern by superposition of two identical speckle fields, each being a redundant Fourier transform of the original transparency-object. The conditions for extraction of the difference image are established on the basis of this analysis. For experimental verification, the procedure was applied to a standard template and a diffuse scatterer through which that template was illuminated. During the intervals between exposures, the central part of the illuminated region was covered with an opaque rectangular shield so as to differentiate the two speckle fields, and at the same time either the object was moved transversely through a distance of 10-25  $\mu\text{m}$  or the flat reference light beam was deflected through a  $1^\circ$  angle. An analysis of the results reveals that space filtration precisely at the interference minimum will suppress the identical regions of the two compared images. Since the restoring light beams have finite apertures, increasing their diameter will shrink the speckles and thus improve the resolution, but will also brighten the background and thus increase the noise. Optimization of the image subtracting process therefore entails a tradeoff. The signal-to-background ratio, an optimization criterion, is determined by both the radius of the light beam and the period of the interference pattern. It is found to depend on the location of the filter relative to the interference maximum. The authors thank V.P. Ryabukho for helpful discussion. Figures 5; references 8: 2 Russian, 6 Western.  
[554-2415]

## FEASIBILITY OF USING GRADIENT LENSES IN MINIATURE OPTICAL DATA PROCESSING DEVICES

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 55, No 7, Jul 85  
(manuscript received 12 Dec 83) pp 1354-1356

GUROV, Yu.V., ILIN, V.G., KARAPETYAN, G.O., KANAYEV, A.Ye., KOSHARNOVSKIY, A.N., REMIZOV, N.V. and TIKHOMIROVA, L.B., Leningrad Polytechnic Institute imeni M.I. Kalinin

[Abstract] Use of gradient lenses as collimators of injection-laser radiation in holographic memories is considered as a way to miniaturize such devices. The feasibility was studied and established experimentally with lenses 1 mm in diameter having a parabolic radial profile of the refractive index ( $n_0 = 1.59$  at the axis,  $\Delta n = 0.0068$  drop from axis to surface) and a numerical aperture NA - 0.15, their length  $L = 8.5$  mm having been selected on the basis of the  $L = \frac{1}{2} \pi r_0 (n_0 / 2 \Delta n)^2$  relation ( $r_0$  - lens radius). Measurements were made with a DGS GaAs/AlGaAs laser diode with average power  $\approx 3$  mW at the  $\lambda \approx 870$  nm wavelength with pumping current  $I_p \approx 290$  mA, and an optoelectronic image converter. The laser diode was mounted rigidly, while the gradient lens could be moved in any of three principal directions with a 10  $\mu$ m precision. On the basis of light beam measurements, the collimation efficiency of 10 sample lenses as a function of transverse and normal lens displacements and the energy distribution in the collimated beam were then determined. A layer of immersion fluid with a refractive index  $n_1 = 1.515$  between laser diode and gradient lens did in some cases increase and in other cases decrease the collimation efficiency, depending on whether reduced reflection of the laser beam by the lens face or reduced Q-factor of the diode resonator (lower reflection coefficient of the mirror in fluid than in air) was predominant. Equipment consisting of a semiconductor laser and a gradient lens was also used experimentally and with success for reconstruction of a real image from its Fourier hologram. A regular array consisting of a row of lenses and a row of diodes appears to be the most expedient configuration. Figures 4; references: 4 Russian.  
[554-2415]

## RESONANT TRANSFORMATION OF LIGHT BY RELATIVISTIC ION BEAMS

Moscow ZHURNAL EKSPERIMENTALNOY I TEORETICHESKOY FIZIKI in Russian Vol 89, No 1 (7), Jul 85 (manuscript received 4 Mar 85) pp 66-70

BASOV, N.G., ORAYEVSKIY, A.N. and CHICKHOV, B.N., Institute of Physics imeni P.N. Lebedev, USSR Academy of Sciences

[Abstract] Interaction of an ion beam moving at nearly the velocity of light and a beam of light quanta moving in the opposite direction is analyzed in two systems of coordinates, the laboratory system and a system tied to the ion beam so that the three axes of each remain correspondingly

parallel. In the moving system of coordinates, there takes place a deflection of the light beam and, along with the change of angle, also a change of frequency in accordance with the Doppler effect. Geometrical and energy relations reveal a transformation of light by scattering with an appreciable upward frequency shift. The energy balance, based on isotropic scattering and also including absorption of light quanta by the ion beam, yields the intensity of scattered light and the efficiency of such a transformation at resonance. Three mechanisms make scattering by a moving ion differ quantitatively from scattering by a quiescent one. The "projector" effect lowers the ratio of scattered light quanta to total light quanta by the factor  $\Omega/4\pi$ , because light scattered over a  $\frac{1}{2}\pi$  sector is collected within an  $mc^2/E$  sector. While the Doppler effect increases the ratio of scattered radiation energy to laser radiation energy by the factor  $(E/mc^2)^2$ , pulse contraction increases the ratio of corresponding intensities by another factor  $(E/mc^2)^2$ . Numerical estimates for Be-III and B-IV ion beams of up to 100 GeV energy (ion mass 10 GeV,  $E/mc^2 = 10$ ) indicate the feasibility of efficiently transforming visible laser light into ultraviolet or X-radiation at resonance with the  $1s^2-1slp$  transition. The authors thank A.A. Komar, Ye.A. Yukov, and M.N. Yakimenko for helpful discussions. References 9: 6 Russian, 3 Western. [553-2415]

UDC 621.373.826

# STUDY OF QUALITY OF THREE-DIMENSIONAL APPROXIMATION OF A WAVE FRONT WITH ZONAL-MODAL CORRECTION

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 6, Jun 85  
(manuscript received 3 May 84) pp 1-3

DIMOV, N.A., KORNIYENKO, A.A., MALTSEV, G.N. and PECHENOV, A.S.

[Abstract] The question of the accuracy approximation of a wave front has been studied previously, usually individually for the zonal (element by element) or modal (aberration) methods of wave front control. This article presents an attempt to study the problem by a combination of zonal and modal control methods, achieving a zonal-modal correction by, for example, controlling both the displacement of individual subapertures and the general inclination of the entire group of apertures. The search for a structure of an adaptive system acceptable from the standpoint of the relationship between quality of correction achieved and complexity of control is found to be related to the quantitative estimation of approximation quality as a function of the combination of the types of control actions with a fixed number of subapertures. In many practical situations the zonal-modal method of controlling correcting apertures can significantly increase the quality of distortion correction of a wave front of an optical beam. The method here suggested, due to the performance of transforms in the area of three-dimensional frequencies, allows determination of the Strehl coefficient for the adaptive optical system over a broad range of values of  $d/r_0$ . Figures 3; references 7: 6 Russian, 1 Western. [523-6508]

UDC 621.373.826

# REFRACTION BY WIND ALONG HOMOGENEOUS PATH IN PARAXIAL APPROXIMATION

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 30 Jul 84) pp 884-886

KOLOSOV, V.V., Institute of Atmospheric Optics, Siberian Department, USSR Academy of Sciences

[Abstract] The problem of light beam propagation with nonlinear refraction in a windy atmosphere is solved in the paraxial aberration-free approximation on the basis of three second-order negative-degree differential equations describing, respectively, diffraction, refraction, and lateral shift in a steady wind. The approximation yields an analytical expression for the change in the maximum radiation intensity and the shift of the intensity peak, while the variational aberration-free approximation describes the change in the effective dimensions of a light beam and the shift of its energetical center of gravity. The equation of diffraction can be solved analytically, and exactly when the attenuation is negligible, but the other two equations can be solved only approximately and with the aid of empirical relations. A numerical solution to the problem is given for an axisymmetric initially Gaussian light beam, with  $\xi = L_r^2/L_c^2 = 1$  ( $L_r$  - characteristic refraction length,  $L_d$  - characteristic diffraction length), as well as with  $\beta \gg 1$  corresponding to negligible dependence on refraction and  $\beta \ll 1$  corresponding to negligible dependence on diffraction. The results agree with the solution to the problem of wind effect on a laser beam, obtained by a numerical method by P.A. Konyayev. Figures 2; references: 5 Russian.

[456-2415]

UDC 621.373.826

# ATTAINABLE CHARACTERISTICS OF PHASE-CONJUGATE ADAPTIVE SYSTEM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 7 Jun 84) pp 815-819

ALEKSANDROV, A.B. and DOLOTIN, Yu.G.

[Abstract] Adaptive correction of the wavefront of optical signals, the most effective way to compensate phase distortions in a turbulent atmosphere, is

in the case of a phase-conjugate adaptive system is limited by both measurement error and compensation error. The measurement error occurs in determining the phase of the reference-radiation wavefront. The compensation error occurs subsequently in correcting the measured phase distortions. For establishing the attainable levels of adaptation speed and accuracy, first the optimum algorithm of estimating phase distortions is synthesized and then the statistical characteristics of this algorithm are analyzed. An additive incoming mixture of regular signal from a point object and  $\delta$ -correlated normal noise is considered as the simplest case, for which the maximum-likelihood estimator of wavefront phase in a receiver subaperture is then accordingly formulated. The performance of a phase-conjugate transmitting adaptive system is evaluated, considering that the signal-to-noise ratio in a subaperture is proportional to the radiation intensity in the plane of the object and assuming an approximately log normal probability density distribution of the signal-to-noise ratio without adaptation. It is evaluated in the terms of the Strehl factor, which depends on the number of subapertures in the adaptive system and which in each adaptation cycle is a function of its mean value in the preceding adaptation cycle. Quantitative estimates reveal a limitation on the efficiency of phase distortion compensation by this method, a limitation related to the signal-to-noise ratio in a homogeneous medium. When the latter is sufficiently high,  $(s/n)_{\text{homo}} \gtrsim 3$ , then a phase-conjugate system corrects efficiently with a Strehl factor  $S \approx 1$  no matter how small but larger than zero the initial signal-to-noise ratio is. With  $(s/n)_{\text{homo}} \lesssim 1$ , however, a phase-conjugate system will eventually reach an inefficient steady state with the Strehl factor  $S \ll 1$  when the initial signal-to-noise ratio is  $(s/n)_{\text{init}} \lesssim (s/n)_{\text{homo}}$ . The results also indicate that a phase-conjugate adaptive system allows increasing the transmitter-receiver aperture without change in the subaperture dimension and without appreciable degradation of performance, unlike aperture probing where widening the light beam without change in the subaperture dimension will proportionally decrease the signal-to-noise ratio in the measuring system. Figures 3; references: 5 Russian. [456-2415]

UDC 621.373.826.038.825.3

# THEORY OF CASCADED THIRD-HARMONIC GENERATION IN APPROXIMATION OF STRONGLY INTERACTING WAVES

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 15 May 84) pp 772-778

IBRAGIMOV, E.A., SAMIGULIN, K.R. and USMANOV, T., Institute of Electronics imeni U.A. Arifov, UzSSR Academy of Sciences, Tashkent

[Abstract] Cascaded third-harmonic generation in anisotropic media is comprehensively analyzed in the approximation of strongly interacting waves, taking into account the divergence of real light beams. Calculations are

based on two schemes with two crystals not requiring additional plates for rotating the polarization axes and matching the phases of light beams. In the first scheme, there are two crystals with second-kind ooe-eoe interaction, polarization of the incident light beam at  $\phi \approx 35.2^\circ$  to the principal optical plane of the first crystal ensuring a 1:2 energy ratio of the two waves mixing in the second crystal, but optimum modulation requiring a slightly different polarization angle. In the second scheme, there are two crystals with first-kind ooe-ooe interaction, polarization of the incident light beam at  $\phi \approx 35.2^\circ$  to the principal optical plane of the first crystal ensuring maximum conversion efficiency even with space-time modulated light beams and allowing this efficiency to approach 100% - in the ideal case of nondivergent incident light beams. In the second scheme, however, angular dispersion of real light beams does appreciably limit the efficiency. Calculations for both schemes are based on the system of equations describing the interaction of three waves in a quadratically nonlinear anisotropic medium. These equations simplify for incident light beams with small divergence and large aperture. Their solution for the appropriate boundary conditions, assuming spherical incident wavefronts and no incident third wave, applies to both crystals. A comparative evaluation of both schemes, based on numerical data pertaining to KDP crystals and typical power lasers, indicates that with incident light beams in the practical range  $G = \theta/\sqrt{W} \leq 5 \cdot 10^{-5}$  cm/GW $^{1/2}$  ( $\theta$  - divergence angle,  $W$  - power density) the optimum length ratio of the two crystals for maximum third-harmonic generation efficiency does not depend on the referred light beam divergence: in the oeo-eoe scheme, the second crystal should be 1.3 times longer, and in the ooe-ooe scheme, the first crystal should be 1.7 times longer. Figures 5; references 11: 5 Russian, 6 Western.  
[456-2415]

UDC 535.361.2

#### LIGHT SCATTERING BY MICRORELIEF OF MIRROR SURFACE

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 2, Feb 85  
(manuscript received 31 May 84) pp 14-16

CHEKMAREV, V.M.

[Abstract] The results of a study of the scattering properties of mirror surfaces are presented, and the possibility of estimating mirror roughness is demonstrated. An experimental approach is described in which the regular nature of the spatial distribution of the light scattered by mirrors with highly polished surfaces that differ significantly in the intensity of diffuse scattering can be identified. The light distribution is regular in that the indexes, represented on a logarithmic scale, exhibit a long linear segment. It is shown possible to estimate the height of microscopic irregularities of mirror surface on the basis of this regularity. Figures 4; references 6: 3 Russian, 3 Western.  
[418-6900]

## PROPERTIES OF OPTICAL MIRROR LOOP

Leningrad OPTIKO-MEKHANICHESKAYA PROMYSHLENNOST in Russian No 2, Feb 85  
(manuscript received 30 May 84) pp 25-27

DRIK, F.G.

[Abstract] A study is made of the properties of an optical mirror loop, consisting of a system of flat mirrors arranged so that a beam of light, e.g., from a laser, is reflected successively and forms a loop trajectory lying in one plane. If one of the mirrors is moved, with the others remaining still, the length of the optical path of the light beam and the spatial position of this trajectory change. Analytical expressions are derived that show that these changes depend upon the parallel displacement of the mirror, as well as the angles of incidence of the light beam on both of its surfaces. When the sum or difference of the angles of incidence of the light beam is equal to  $\pi$ , the difference in the length traveled on both sides of the bilateral mirror are compensated, so that the original length of the optical path remains unchanged, producing a compensating optical loop. Compensating optical loop schemes can be used in holographic and other coherent optical systems that require stable phase relationships of the light beams when moved with respect to one another in space.

Figures 4.

[418-6900]

## COMPONENTS OF INTEGRATED OPTICS AND MAIN DEVELOPMENT TRENDS (REVIEW)

Kiev OPTOELEKTRONIKA I POLUPROVODNIKOVAYA TEKHNKA in Russian No 6, 1984  
(manuscript received 25 Mar 83) pp 60-71

SVECHNIKOV, G.S., Kiev Branch, Odessa Institute of Electrical Communication Engineering imeni A.S. Popov

[Abstract] The fundamental requirement for progress in integrated optics is development of components, optical analogs of microwave devices, by various waveguide techniques. The basic components assemblable on a single substrate are thin-film dielectric waveguides, light sources and photoreceivers, filters and switches. A need for necessarily low control voltages, high modulation and switching speeds, high stability of optical channels, and compatibility with fiber-optic transmission lines has set the trend toward extensive use of lithium niobate as base material. The excellent electrooptical and acoustooptical properties of  $\text{LiNbO}_3$  crystals make them eminently suitable for such devices as modulators and switches in the gigahertz frequency range, the main problem being adequate size miniaturization. Better surface utilization by twinning  $\text{LiNbO}_3:\text{Ti}$  crystals

or by combining  $\text{LiNbO}_3$  crystals with thin-film waveguides, particularly surface-acoustic-wave channels ( $\text{Nb}_2\text{O}_5$  and  $\text{ZnS}$  films separated by  $\text{Ta}_2\text{O}_5$  film) have greatly enhanced the possibilities of integration. Optical components based on these elements include bistable devices and spectrum analyzers, while various  $\text{A}^{\text{III}}\text{B}^{\text{V}}$  and  $\text{A}^{\text{II}}\text{B}^{\text{VI}}\text{C}^{\text{VI}}$  compound semiconductor materials are structured for extensive use as sources of coherent light, such as lasers with distributed feedback or with distributed Bragg reflection, ring lasers, and others. Integration varies in base, form, and degree of complexity. It can be unifunctional combining components of one kind or multifunctional combining components of different kinds, it is horizontal or vertical, and its complexity extends to lattice structures and multilayer structures, such as mesh arrays of filters and linear arrays of photodiode receivers on silicon substrates for demultiplexing, and even more intricate structures for multiplexing. Figures 9; references 100: 12 Russian, 88 Western (3 in Russian translation).  
[585-2415]

UDC 621.317.757.13+535.81

# MEASUREMENT OF TIME CHARACTERISTICS OF OPTICAL ELEMENTS WITH FEMTOSECOND RESOLUTION

Gorky IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian  
Vol 28, No 6, Jun 85 (manuscript received 6 Jun 84) pp 798-800

VVEDENSKIY, Yu.V., ZUYEV, A.B. and SIZMIN, A.M., Radiophysics Scientific Research Institute

[Abstract] Development of methods for generation of picosecond and femtosecond optical pulses requires the development of measurement methods for brief time intervals. The time characteristics of linear devices are exhaustively described by the pulse transient function  $g(t)$ , requiring measurement of instantaneous values of very short processes. It is easier to measure the intensity of optical signals. Determination of  $g(t)$  from intensities requires solving the problem of generation and measurement of optical pulses which are shorter than the characteristic settling times in the system being studied. The task of measuring  $g(t)$  in optical elements can be performed using an equation presented in this article. The time resolution of a measuring device is determined by the correlation interval of the test signal and the working band of the optical correlometer.  
[543-6508]



## APPLICATION OF BINARY CORRELATION FOR IMAGE RECOGNITION

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 29, No 5, 1985 (manuscript received 16 Apr 84) pp 4210423

KHILO, N.A., Gomel State University

[Abstract] Instead of the autocorrelation or cross-correlation function formed as the result of matched spatial filtering in optical image recognition, it is shown for a certain class of distortions of the input images with respect to the patterns that a binary correlation function  $K_{12}(r) = K_1(r) \otimes K_2(r)$  can be used, where  $\otimes$  denotes correlation;  $K_1$ ,  $K_2$  are first-order correlation functions, and  $r = (x, y)$ . An optical correlator is shown that implements the binary autocorrelation method. Figures 1; references 2: 1 Russian, 1 Western [442-6900]

## CHANGE IN POLARIZATION STRUCTURE OF OBLIQUE BEAMS ON NATURAL LIGHT BY LENS SYSTEMS

Minsk VESTSI AKADEMII NAVUK BSSR in Russian No 2, Mar-Apr 85 (manuscript received 26 Jul 83) pp 68-73

LAMEKIN, P.I. and PREDKO, K.G., Mogilev Section, Physics Institute, Belorussian Academy of Sciences

[Abstract] In any system for forming and transmitting an optical image, the points of objects not lying on the optical axis are represented by oblique light rays. This article examines the polarization transformation of oblique beams of natural light by lens systems as a continuation of a previous study by the authors (VESTSI AN BSSR: SER. FIZ.-MAT. NAVUK, No 2, pp 106-110, 1983). The problem is formulated as follows. It is assumed that a parallel beam of natural light is incident to a lens system containing  $k$  refracting surfaces at an angle  $\alpha_0$  to the optical axis. Beam geometry and polarization characteristics are described in a Cartesian coordinate system referenced to the apex of the first refracting surface with the  $z$ -axis directed along the optical axis and oriented in such a way that the incident beam is parallel to the  $yz$  coordinate plane. In the initial beam, an arbitrary ray with intensity  $I_0$  is discriminated which is incident on the first refracting surface at a point with the polar coordinates  $\rho(x, y)$  and  $\varphi(x, y)$ . Under these conditions, the refracted ray will be partially linearly polarized. A specific example of computations is given. The study revealed that the polarization structure of

oblique light beams passing through the lens system has a complex nature both with respect to the degree of linearity of polarization and with respect to the azimuth of the linearly polarized component of beam rays. The degree of linearity of beam rays polarization can vary from zero to several tens of percent and the azimuth can assume any value from  $-\pi/2$  to  $\pi/2$ . This polarization structure exerts an important influence on the energetic and informational characteristics of the optical image in systems containing polarization and anisotropic elements. Figures 2; references 7: 6 Russian, 1 Western.  
[399-5303]

UDC 519.21

STATISTICAL STRUCTURE OF PHOTODETECTOR COUNT DURING RECORDING OF MULTIBEAM INTERFERENCE OF NONCOHERENT RADIATION WITH LORENTZIAN SPECTRAL LINE CONTOUR

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 6, Jun 85 (manuscript received 27 Feb 84) pp 53-55

LASKIN, N.V. and MAZMANISHVILI, A.S., Kharkov Institute of Engineering Physics

[Abstract] Photodetection of noncoherent radiation through multibeam interference patterns, specifically of radiation with a Lorentzian spectral line contour, is analyzed statistically on the basis of known relations for such an interference and with reference to the theory of optical coherence. The generating function of photodetector count is found to have the same structure as the Mandel generating function for direct photodetection. Article was presented by Academician (UkSSR Academy of Sciences) A.I. Akhiezer. References 4: 1 Russian, 3 Western (all in Russian translation).  
[557-2415]

UDC 519.21

ESTIMATES OF CORRELATION AND SPECTRAL FUNCTIONS OF HOMOGENEOUS AND ISOTROPIC GAUSSIAN RANDOM FIELD

Kiev TEORIYA VEROYATNOSTEY I MATEMATICHESKAYA STATISTIKA in Russian No 32, 1985 (manuscript received 23 Feb 83) pp 17-27

DYKHOVICHYY, A.A., Engineer, Kiev University

[Abstract] A study is made of the asymptotic properties of empirical estimates of correlation and spectral functions of a Gaussian homogeneous and isotropic random field observed on a sphere. References: 9 Russian.  
[85-6508]

## ORGANIC PHOTOCHROMIC MATERIAL FOR RECORDING WAVEGUIDE HOLOGRAMS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 11, No 6, June 1984, pp 1250-1253

[Article by Yu. A. Bykovskiy, V. A. Barachevskiy, Yu. V. Borodakiy, V. M. Kozenkov, V. L. Smirnov and Yu. V. Shulev: "A Study of Organic Photochromic Material for Recording Waveguide Holograms"]

[Text] A method of recording phase patterns and fixing them in organic photochromic waveguides has been studied experimentally. On the basis of the method studied, the authors have recorded waveguide holograms and studied their selective properties and the spatial intensity distribution in the reconstructed beam. They discuss ways to improve the selectivity of waveguide holograms

Holographic methods of processing and storing information offer vast new possibilities for the development of a whole new class of special-purpose analog optical processors and high-capacity holographic memory devices [1, 2]. The development of integrated optical information processors makes it necessary to be able to configure the hologram to conform to the capacity of the optical waveguide [3-5]. But we achieve optimum interaction between the propagating wave and the hologram if the object wave and the reference wave are modes of the waveguide. The advantage of this method consists in the fact that the hologram is read and recorded in the waveguide by one and same wavelength and one and the same waveguide modes, in consequence of which the hologram is corrected for distortions in the wave front due to the mode structure at different wavelengths, distortions introduced by irregularities in the waveguide and by the input system employed

In previously published studies we have seen waveguide holograms produced in waveguides made of a lithium niobate-iron alloy [6] and gelatin presensitized to the recording wavelength [7]. The search for waveguide hologram material continues, however, because distortions will still appear during the reading process because the hologram has only a short lifetime in  $\text{LiNbO}_3$  [8] and because the layers of gelatine shrink after they set.

The objective of the present study was to study the formation of waveguide holograms in organic, photosensitive waveguides for which indoline spiripirans are used and then to analyze the properties of the resulting holograms.

For our thin-film waveguides we used films made of a butylmethacrylate copolymer with an amide of methacrylic acid and acrylonitrile between 0.8 and 19  $\mu\text{m}$  thick with an additive of indoline spiropiran in concentrations of up to 15 per cent. Films were applied to glass or quartz substrates by centrifuging, pulling or by casting the solution and then letting the solvent evaporate in air. The films were annealed to eliminate inner stress. At a wavelength of 0.63  $\mu\text{m}$  losses in these thin-film waveguides did not exceed 0.5 dB/cm.

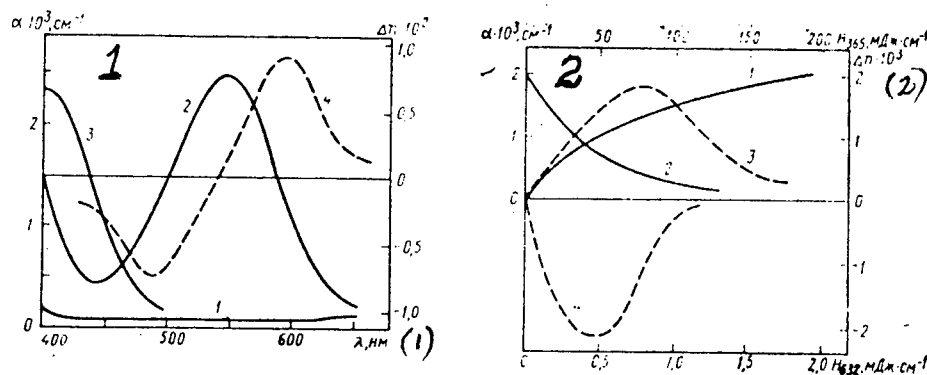


Figure 1. Absorption spectra for initial (1), photoinduced (2) and hydrochloric acid vapor-fixed (3) photochromic waveguide prepared from a solution of ASN-11 (acrylonitrile) and dispersion curve of the change in refractive index (4).

Figure 2. Coefficient of absorption (1, 2) and double refraction (3, 4) as a function of energy of exposure of UV layer (1, 3) and visible radiation (2, 4) with wavelengths of 365 and 632.8 nm respectively

1(1) - nm; 2(2) - MJ

We know [9] that these photochromic compounds undergo reversible photodissociation reactions, which cause a change in the absorption capacity and polarizability of the photochromic compound. Under the effect of the UV radiation ( $\lambda \leq 400 \text{ nm}$ ), the films, initially transparent in the visible range of the spectrum (attenuation in waveguide less than 1 dB/cm when  $\lambda \approx 0.63 \mu\text{m}$ ) (Figure 1, curve 1), take on color (Figure 2, curve 2). The original state is restored under the effect of visible light or in the process of dark relaxation. Figure 2, curves 1 and 2, shows the kinetic curves of coloration and bleaching of the photochromic layer under the effect of illumination from a DRSh-250 lamp and a helium-neon laser. The change in the absorption spectra here is accompanied by photoinduced changes in the refractive index  $\Delta n$  (Figure 1, curve 4). As can be seen in the figure, the greatest change in  $\Delta n$  is to be observed in the region of anomalous dispersion, that is, within the limits of the photoinduced change in the absorption band.

When these photochromic waveguides are illuminated by a polarized beam of activating light, the photoinduced change in the combined refractive index has an anisotropic component. This phenomenon is known as the Weigert [Veygert] effect

and is due to the fact that the probability of absorption and, accordingly, the occurrence of a photochemical reaction is proportional to the square of the cosine of the angle between the direction of the dipole moment of the molecular transition and the polarization vector of the activating radiation. The direction from the tensor of dielectric permittivity will in this instance coincide with the polarization vector of the recording radiation, while the magnitude and shape of the kinetic curve of induced optical anisotropy are themselves functions of the energy and wavelength of the activating radiation. Figure 2, curves

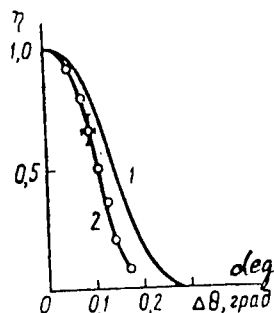


Figure 3. Curves of angular halfwidth of Bragg resonance (1 - computed; 2 - experimental) for a waveguide hologram in a thin-film waveguide

3 and 4, shows the dependence of the photoinduced change in double refraction  $\Delta n$  when the polarization vectors of the activating and sensing beams as the waveguide is illuminated with UV and visible radiation are parallel and orthogonal respectively as measured at  $\lambda \sim 0.63 \mu\text{m}$ . The difference in the signs of the induced double refraction is due to the fact that the absorption oscillators in the UV and visible regions of the spectrum form a fairly large angle. The time required for dark relaxation induced in the optical anisotropy layer is governed for the most part by the rotary Brownian motion of the photoselected molecules and at room temperature runs to 10-15 min.

For reversible fixation of holograms recorded in photochromic waveguides, we process them in HCl vapor for 2-3 min [4]. The spiropiran now induced forms a complex with the HCl molecules, the absorption spectrum of which is shifted to the shortwave range (Figure 1, curve 3). The volume phase hologram thus produced allows us to read on the recording wavelength, although after treatment in HCl vapor the diffraction efficiency will be degraded 1.5-2-fold and not exceed 30 per cent, what with the fact that the reading wavelength lies outside

the region of anomalous dispersion for the complex. The recording is reversible, and the phase pattern is erased after the waveguide hologram is treated with a caustic agent, ammonia for example, for 3-4 min due to destruction of the complex and restoration of the initial state of the spiropiran.

To fix the waveguide holograms we made irreversibly we treated them with cyclohexane; since with illumination by UV radiation the photoinduced tuning of the spiropiran molecules causes an increase in the density of these molecules and a change in solubility in organic solvents, the initial, colorless spiropiran is washed from the waveguide.

We recorded our waveguide hologram using the conventional two-beam system with UV activation of the point where the beams intersect. Radiation on a wavelength of  $0.63 \mu\text{m}$  was input and output by way of a TF-5 glass prism; the width of the light beam in the waveguide did not exceed 0.35 mm, intensity varying between 0.8 and  $12 \text{ W/cm}^2$ . The beam convergence angle in the waveguide varied between  $1^\circ$  and  $15^\circ$ , which corresponds to the change in period from 11 to  $0.7 \mu\text{m}$ . The hologram was recorded essentially by exciting the TE modes of the waveguide with beams of identical intensity.

Diffraction efficiency  $\eta$  was measured by overlapping one beam with the other. Figure 3 shows normed diffraction efficiency as a function of angular detuning from the optimum angle of incidence of the reading beam with the hologram  $\Delta\theta$ . Computed relationships are shown for the TE<sub>0</sub> mode of a four-mode waveguide (effective refractive index  $n_0^* = 1.598$  on a wavelength of  $0.6328 \mu\text{m}$ ) interacting on the diffraction grating with a period  $\Lambda = 1.6 \mu\text{m}$  and a jump in refractive index  $\Delta n = 6.7 \cdot 10^{-4}$  ( $\Lambda$  and  $\Delta n$  representing mean period and jump in refractive index on hologram). Figure 4 shows adjusted diffraction intensity as a function of the number of interacting modes  $m$  for a waveguide hologram recorded in the zero-order mode and the distribution of intensities among the modes of the waveguide over the period of the recording. The slight difference in the curves in Figure 4 is due to the nonlinear sensitivity of the material as well as to the mode selectivity of the waveguide hologram itself. As can be seen in Figure 3, the spatial-angular selectivity of the hologram produced experimentally is somewhat greater than the theoretical selectivity. This is due to the fact that  $\Delta n$  and the period of the hologram are in fact never identical anywhere.

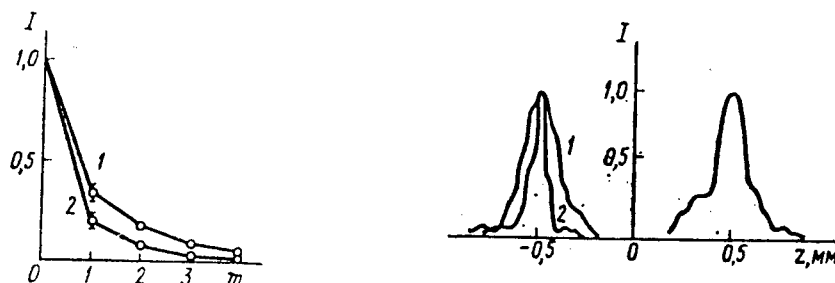


Figure 4. Adjusted diffraction intensity  $I$  as a function of number of interacting modes  $m$  (1) and adjusted diffraction intensity  $I$  as a function of number of interacting modes  $m$  during recording (2).

Figure 5. Normed spatial distribution of beam intensity after output prism before sensitization of the waveguide (1) and in the diffracted wave after the hologram is fixed (2)

Figure 5 shows the spatial distribution of beam intensity after the output prism prior to sensitization of the area in which the beams intersect. As the hologram is recorded, we can observe a certain redistribution of output intensity between the beams. This is due to diffraction of the recording radiation on the hologram during the recording process. The slight spatial nonuniformities in beam intensity are apparently due primarily to irregularities in the coupling regions and in the waveguide itself. The spatial nonuniformity  $\Delta n$  is due primarily to spatial nonuniformities in the recording beams. It is interesting to note that the spatial distribution of intensities in the diffracted wave (Figure 5, curve 2) is considerably narrower than it is in the recording wave, which is due to the characteristic shape of the waveguide hologram [10] and to the decrease in  $\Delta n$  perpendicular and parallel to the direction of propagation of the recording beams and the reduction in the effective dimensions of the hologram associated with this.

The selectivity of the waveguide hologram, however, as well as of the diffraction gratings can be either increased or decreased in the production of anisotropic holograms, whose selectivity we can control by varying not only  $\Delta n$  and the angle between the recording beams, but also by rotating the optical axis [11]. This type of hologram can be recorded in the waveguides studied here (Figure 3, curves 3 and 4), but to fix them will clearly still require improvements in both the material and the fixing process itself.

So in this study we have been looking at the process of recording waveguide holograms in spiropiran-based photochromic waveguides. We have demonstrated the possibility of both reversible and irreversible fixation of the holograms, studied the parameters and selective properties of the holograms produced and, finally, have been able to narrow the curve describing the spatial distribution of intensities in the reconstructed beam.

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Moscow Institute of Physics and Engineering

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8963

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SCIENTIFIC SOVIET OF THE ACADEMY OF SCIENCES OF THE USSR ON THE PROBLEM  
OF 'COHERENT AND NONLINEAR OPTICS'

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 pp 895-896

[Unsigned article in "Information" Section]

[Text] On September 1984 the Presidium of the USSR Academy of Sciences approved the revised composition of the Scientific Council of the USSR Academy of Sciences on the Problem of "Coherent and Nonlinear Optics." The Soviet includes the leading scientists of the Soviet Union who are working in this area--Academicians Zh.I. Alferov, N.G. Basov, N.A. Borisevich, A.V. Gaponov-Grekhov, V.Ye. Zuyev, L.V. Keldysh, and A.M. Prokhorov; Corresponding Members of the USSR Academy of Sciences A.M. Bonch-Bruyevich, F.V. Bunkin, N.V. Karlov, A.L. Mikaelyan, M.M. Mirosnikov, S.G. Rautian, K.K. Rebane, N.D. Ustinov, P.K. Khabnbulayev, and V.P. Chebotayev; Academician of the Armenian SSR Academy of Sciences M.L. Ter-Mikayelyan; Academicians of the Belorussian SSR Academy of Sciences P.A. Apanasevich, A.M. Goncharenko, and B.I. Stepanov; Academician of the Ukrainian SSR Academy of Sciences M.S. Brodin; Corresponding Members of the Belorussian SSR Academy of Sciences V.S. Burakov and A.N. Rubinov; and Corresponding Member of the Ukrainian SSR Academy of Sciences M.T. Shpak, as well as 31 doctors and 6 doctoral candidates in the sciences (a total of 62 people) from institutes of the academies of science and higher educational institutions.

The Chairman of the Scientific Council is Corresponding Member of the USSR Academy of Sciences F.V. Bunkin.

The Deputy Chairmen are Dr (physics-mathematics) S.A. Akhmanov and PhD Candidate (technical science) M.F. Bukhenskiy.

The Scientific Secretary is PhD Candidate (physics-mathematics) V.D. Novikov.

The members of the Council Bureau are: Academician of the Belorussian SSR Academy of Sciences P.A. Apanasevich, Dr (physics-mathematics) V.I. Bespalov, Corresponding Member of the USSR Academy of Sciences A.M. Bonch-Bruyevich, Academician of the Ukrainian SSR Academy of Sciences M.S. Brodin, Corresponding Member of the USSR Academy of Sciences N.V. Karlov, Dr (physics-mathematics) V.S. Ketokhov, Dr (physics-mathematics) A.N. Orayevskiy, and Corresponding Member of the USSR Academy of Sciences V.S. Chebotayev.



The job of the Council is to coordinate basic research in the USSR in the following specializations:

- solid-state laser (crystal and glass lasers, semiconductor lasers);
- gas lasers;
- liquid lasers;
- the development of new methods of making lasers;
- lasers in the ultraviolet and X-ray ranges, gamma lasers;
- far-IR lasers,
- frequency-tunable lasers;
- nonlinear optics;
- integrated optics;
- fundamental problems in creating and improving the elemental devices used in quantum electronics;
- superhigh-resolution nonlinear laser spectroscopy and laser spectral analysis;
- the development of new methods of receiving and recording laser radiation;
- lasers in optical information processing;
- optical fiber communications systems using lasers;
- the use of lasers for controlled thermonuclear synthesis;
- the fundamental problems of the interaction of laser radiation with matter;
- the technological applications of lasers;
- the application of lasers in chemistry (laser photochemistry);
- the application of lasers for isotope separation;
- the application of lasers in biology and medicine;
- quantum standards for frequency, time, and length;
- laser sensing of the atmosphere;
- the propagation of laser radiation in various media;
- other applications of lasers in science and technology.

The Scientific Council of the USSR Academy of Sciences on the Problem of "Coherent and Nonlinear Optics" includes the following as its departments (branches):

The Scientific Council of the Belorussian SSR Academy of Sciences on the Problem of "Optics" (Chairman - Academician of the Belorussian SSR Academy of Sciences B.I. Stepanov, Deputy Chairman - Corresponding Member of the Belorussian SSR Academy of Sciences A.N. Rubinov, Scientific Secretary - PhD Candidate (physics-mathematics) V.V. Churakov);

The Scientific Council of the Lithuanian SSR Academy of Sciences on the Problem of "Laser Optics and Spectroscopy" (Chairman - Academician of the Lithuanian SSR Academy of Sciences Yu.K. Vishchakas, Deputy Chairman - Dr (physics-mathematics) A.S. Piskarskas, Scientific Secretary - PhD Candidate (physics-mathematics) V. Kabelka);

The Scientific Council of the Ukrainian SSR Academy of Sciences on the Problem of "Quantum Electronics" (Chairman - Corresponding Member of the Ukrainian SSR Academy of Sciences M.T. Shpak, Deputy Chairmen - Academician of the Ukrainian SSR Academy of Sciences M.S. Brodin and Dr (physics-mathematics) M.S. Soskin, Scientific Secretary - PhD Candidate (physics-mathematics) Ye.N. Salkova).

The address of the Scientific Council of the USSR Academy of Sciences on the Problem of "Coherent and Nonlinear Optics" is: 117942, GSP [city

official mail system], Moscow, V-333, ul. Vavilova, 38, IOFAN [Institute of General Physics of the Academy of Sciences]. Telephone numbers: 135-82-34 (F.V. Bunkin), 135-82-96 (M.F. Bukhenskiy), 139-12-25 (S.A. Akhmanov), 234-21-89 (V.D. Novikov).

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2412

CSO: 1862/066

COMPUTER SIMULATION OF PROCESSES IN SOLID-STATE LASER OSCILLATORS AND  
AMPLIFIERS WITH PHOTOTUBE PUMPING: ELECTRIC-DISCHARGE PUMPING SOURCES.  
BASIC PHYSICAL PROPERTIES OF PLASMA IN PUMPING SOURCES

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 95, 1984 KVANTOVAYA ELEKTRONIKA

BASOV, N.G., GRADOV, V.M., ZHILTSOV, V.I., KROMSKIY, G.I., SKLIZKOV, G.V.,  
TERENTYEV, Yu.I., FEDOTOV, S.I. and SHCHERBAKOV, A.A.

[Abstract] Physical properties of plasmas in electric-discharge phototubes for pumping of solid-state laser devices are analyzed, to provide the necessary basis for computer simulation of processes in such pumping sources according to a consistent and universal, as well as rigorous and complete, but also sufficiently simple mathematical model which covers a broad class of laser radiators and amplifiers. The properties which determine the energy characteristics of such pumps include thermodynamic ones (statistical sums, plasma composition, specific heat), optical ones (absorption coefficients in continuous spectrum, and in discrete line spectrum according to nonadiabatic theory), and transport properties (thermal and electrical conductivities, diffusion coefficients). Data are given pertaining to a cold and only slightly nonideal plasma in the state of local thermodynamic equilibrium in pumps with either continuous or pulse discharge, in vapors of alkali metals (2000-5000 K,  $\leq 0.1$  MPa) or in inert gases, such as krypton (3000-11,000 K, 0.5-2.5 MPa) or xenon (3-20,000 K, 0.5-2.5 MPa). The effect of plasma nonideality is estimated on the basis of differences between theoretical and experimental data, especially significant in the case of a dense plasma. Figures 11; tables 6; references 128: 102 Russian, 26 Western.  
[437-2415]

# SPACE-TIME STRUCTURE OF RADIATION ATTENDING INTERACTION OF LASER-PLASMA JET AND SOLID SURFACE

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 82, 1984 FIZIKA PLAZMY

PIROGOVSKIY, P.Ya. and SHEVELKO, A.P., Spectroscopy Laboratory

[Abstract] Interaction of a laser-plasma jet and a solid surface was studied in an experiment, for determining the space-time structure of attendant radiation in the visible region of the spectrum and the space distribution of attendant x-radiation. The plasma for this study was produced by second-harmonic radiation ( $0.53 \mu\text{m}$  wavelength) from a Nd-glass laser emitting pulses of 2 ns duration and 4-8 J energy. The radiation was focused by a lens with 300 mm focal length on a plane magnesium target at a  $45^\circ$  angle to the laser beam, to ensure a radiation flux density approaching  $10^4 \text{ W/cm}^2$  over a spot approximately  $8 \mu\text{m}$  in diameter. A plane aluminum barrier was placed in the path of magnesium plasma propagation, normally to the axis of plasma jet dispersal. Visible radiation over the 4000-7000 Å range of wavelengths was recorded with time sweeping in an electron-optical camera with UMI-93 polyalkali photocathode, through an objective with x10 magnification and interference filters. Simultaneously, x-ray images of the plasma jet were recorded in a camera obscura. Processing of the photographs and radiographs has revealed three zones in the space-time domain: zone I adjacent to the target during free quiescent dispersal of the plasma jet; zone II at the barrier surface during interaction of plasma jet and target surface; zone III complete dispersal of plasma jet. The dispersal velocity increased asymptotically to  $5 \cdot 10^7 \text{ cm/s}$  during action of a laser pulse and the velocity of the plasma front reached  $8 \cdot 10^6 \text{ cm/s}$  after the end of a laser pulse, interaction of plasma jet and target surface being accompanied by glow at the target surface and at the front of the shock wave leaving the target surface at a velocity of  $10^7 \text{ cm/s}$ . The authors thank I.L. Beygman, M.A. Mazing, L.P. Presnyakov, A.Ye. Stepanov for interest and constructive discussions, V.L. Artsimovich and Yu.S. Kasyanov for assistance in experiments. Figures 5; references 10: 9 Russian, 1 Western.  
[437-2415]

## ABSORPTION OF RADIATION BY TURBULENT LASER PLASMA

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 119, 1984 FIZIKA PLAZMY

SILIN, V.P., Department of Theory of Plasma Phenomena

[Abstract] Absorption of radiation by a turbulent laser plasma is analyzed, considering that plasma turbulence does not preclude relaxation of laminar processes, such as reverse bremsstrahlung absorption through the electron-ion collision mechanism with either linear or resonant radiation mode conversion. Absorption of radiation is accordingly treated in the linear

approximation first, polarized radiation and Langmuir resonance oscillations presenting the simplest cases. Nonlinearity effects are considered next, taking into account quantum-mechanical factors and departure from the Maxwell distribution of electrons in strong electromagnetic fields. The velocity dependence of hydrodynamic boundary conditions plays a significant role in a moving plasma, while the ponderomotive force also causes a nonlinear redistribution of plasma density and velocity with field containment particularly influential in supersonic electrodynamics. Absorption of strong electromagnetic radiation does in turn produce other nonlinear effects in a laser plasma, among them a broad range of parametric turbulence. These effects are evaluated here in the approximation of linear electron and ion concentration profiles along one of the space coordinates. Another such effect is ion-acoustic instability leading to ion-acoustic turbulence. Figures 20; references 84: 38 Russian, 46 Western. [437-2415]

#### STUDY OF LASER-PLASMA SYSTEM IN 'DELFIN-1' FACILITY

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 207, 1984

ALEKSANDROVA, I.V., ALLIN, A.P., BASOV, N.G., BORISENKO, N.G., BOCHKAREV, V.N., BYKOVSKIY, N.Ye., VADUYEV, A.D., VASIN, B.L., GALICHIY, A.A., HETZ, K., HUNKEL, H., DANILOV, A.Ye., IVANOV, V.V., IVANOV, B.Yu., ISAKOV, A.I., KALASHNIKOV, M.P., KRUGLOV, B.V., KUSCH, S., KORESHEVA, Ye.R., MAZUR, M.Yu., MAKSIMCHIK, A.M., MERKULEV, Yu.A., MIKHAYLOV, Yu.A., NIKITENKO, A.I., ORLOV, V.V., OSETROV, V.P., PUZYREV, V.N., RODE, A.W., RICKER, R., SAVCHENKO, S.M., SKLIZKOV, G.V., SENTSKIY, Yu.V., SOLODKOV, V.M., SUBBOTIN, L.K., FEDOTOV, S.I., FOERSTER, E., TSVETKOV, M.Yu., TSYGANKOV, A.A., CHAUSHANSKIY, S.A., SHELOBOLIN, A.V., SCHENNAGEL, H., SHISHKINA, L.I. and JUNGE, K.

[Abstract] The "Delfin-1" facility has been built for experiments with laser-induced thermonuclear fusion under hydrodynamic compression. The laser-plasma system selected for this facility is one which makes attainment of terawatt laser radiation power feasible. It thus requires amplifier stages with extremely high load capacity and operative at threshold levels for radiation-matter interaction. Heating a target, a thin-walled spherical shell, requires special driving oscillators and shapers of light pulses for an extremely high radiation contrast. Special measures are furthermore required for adequate concentration of laser radiation on the target. All these requirements have been defined and stipulated in terms of laser emission parameters, which have in turn been evaluated from the standpoint of meeting those requirements. One such parameter is the perturbation intensity profile, since small-scale perturbations are a principal limiting factor with respect to radiation intensity at the laser output. Other performance parameters are dependence of the laser beam divergence on the radiation flux density at various critical locations, including nonlinear effects, and on the degree of coherence. The "Delfin-1" facility consists

of a laser module with a driving oscillator and an array of linear pre-amplifiers feeding two parallel amplifier stages, and adjusting system, a synchronizing system, a power supply, and an automatic control system. The laser beam passes through a focusing system and through a diagnostic testing system, both interconnected, into a camera with a vacuum system. This camera covers the laser beam and the diagnosed plasma as well as the target. The "Delfin-1" facility has been designed for measurement of radiation energy, intensity, losses, contrast, spectral content, angular distribution, polarization, and coherence, and of laser beam divergence under steady and transient conditions. Its instruments include a capillary spark shutter, an oscillograph with calibrating attenuator, and an interferometer. The "Delfin-1" facility is interfaced with an RDR-II/04 control minicomputer and standard CAMAC peripheral equipment; it will later also be interfaced with an "Elektronika-60" computer. Figures 21; references 24: 15 Russian, 9 Western.  
[437-2415]

## 'INTERSHOCK' STUDIES PLASMA

Tbilisi ZARYA VOSTOKA in Russian 30 Oct 85 p 3

[Text] The All-Union conference on plasma astrophysics in Tbilisi has ended. Scientists exchanged information on research on space plasma. These studies broaden significantly the body of knowledge gained in controlled thermonuclear fusion laboratories on this state of matter.

"Plasma physics plays a very important role in theoretical research, in understanding the structure of the Universe and in many practical aspects", said Lenin-prize winner Professor A. Galiyev talking to a GruzINFORM correspondent. "Plasma is related to the realization of a controlled thermonuclear reaction. A successful solution to this problem may get mankind around the energy crisis.

In Tbilisi the leading Soviet scientists gathered who study the space plasma under the extreme conditions when tremendous magnetic fields are present, that are billions times stronger than the geomagnetic field, and when enormous temperatures and powerful radiation fields develop. Papers and speeches stated that problems of plasma electrodynamics call for the development of models of magnetic field generation and ways of converting it into thermal energy, energy of accelerating particles and electro-magnetic radiation. Several such models have already been developed in our country. With the help of these models it is possible to explain certain plasma properties under extreme conditions.

This conference was held in Georgia due to the fact that these problems are being actively worked on here. The Georgian school on plasma astrophysics has gained worldwide recognition. Under the direction of Academician Ye. Kharadze, studies on star astronomy are successfully conducted. Theoretical astrophysics under the direction of Corresponding Member of the Republican Academy of Sciences D. Lominadze study the behavior of space plasma on pulsars and around the so called "black holes"; they also study the motion of charged particles in the magnetospheres of neutron stars.

My colleagues and I reported the initial results of the Soviet-Czechoslovak "Intershock" experiment. On April 26, 1985 the first specialized "Prognoz 10-Intershock" satellite was launched into a near-Earth orbit. The satellite is intended for studies of shock waves that are generated when plasma ejected in

supernova explosions or from galactic nuclei collides with space matter surrounding it.

These studies are of fundamental importance in explaining the behavior of objects that are inaccessible for direct studies. The "Intershock" project will make it possible to solve the problem of plasma heating in very strong shock waves.

In May, 1986 the international school on plasma astrophysics will convene in Sukhumi.

12770

CSO: 1862/83



## SPECIFICS OF QUASI-LINEAR DIFFUSION IN RELATIVISTIC MAGNETICALLY ACTIVE PLASMA

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA. SERIYA 3 FIZIKA. ASTRONOMIYA in Russian Vol 26, No 6, Nov-Dec 85 (manuscript received 27 Nov 84) pp 8-12

KUZMENKOV, L.S. and SITNOV, M.I., Department of Theoretical Physics

[Abstract] An attempt is made to show that a transverse magnetic field radically changes the picture of quasi-linear relaxation in a free collisionless plasma. A series of plateaus may be formed in such a field on the three-dimensional distribution function. This effect is not simply a result of relativistic generalization of previous analyses which determined the possibility of formation of a plateau in the distribution function of particles by velocities due to oscillations excited in the plasmas. It is found that transfer of the energy of electrostatic oscillations to plasma electrons can be reduced to two processes: changing of the slope of the one-dimensional distribution function at point  $v_x = u/k$ , and a change in the slope of the three-dimensional function at individual points  $v^\alpha_m$  on the resonant plane  $\omega = kv$ . Figures 1; references 12: 6 Russian, 6 Western. [6508-97]

## PROBE STUDIES OF SHOCK WAVES IN A TRANSVERSE GLOW DISCHARGE PLASMA

Leningrad PISMA V ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 11, No 21, 12 Nov 85 (manuscript received 4 Jul 85) pp 1297-1303

BASARGIN, I.V. and MISHIN, G.I., Physics and Technology Institute imeni A.F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] Results are presented from experiments utilizing single and double electric probes operating in conjunction with a piezoelectric pressure sensor to study shock waves in a glow discharge plasma. The diagnostic methods used allowed data to be obtained on changes in local values of parameters describing the process of transmission of the shock wave through various areas of the plasma. The gas discharge plasma was excited in air at 33 torr, gas temperature in the area of maximum shock wave acceleration about 1070 K, at the center of the discharge about 1400 K. The mean shock

wave velocity outside the plasma was 416 m/s, with plasma present - 850 m/s. The velocities in the first maximum nearest the exit of the shock tube and in the second maximum were 1320 and 1180 m/s. Measurements were performed using a channel forming the shock wave in a shock tube 1200 mm in length, guaranteeing full recombination of charged particles in the pusher gas before it arrived at the plasma column. The results of the experiments indicate an active role of the charged components in the dynamics of the shock wave in the glow discharge. Figures 2; references: 5 Russian. [6508-102]

UDC 537.523.74

#### HF DISCHARGE PLASMA GLOW AT REDUCED PRESSURE

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNIЧЕСKOY FIZIKI in Russian No 5, Sep-Oct 85 (manuscript received 29 Jun 84) pp 3-5

LASHUK, N.A., PROMASEVICH, Ye.T., TOLMACHEV, V.I. and KHAN, V.A., Tomsk

[Abstract] The purpose of this work was to determine spatial changes in the shape of an HF discharge plasma formation as a function of pressure and relative humidity of the air, and to seek conditions providing the minimum volume of the plasma and determine some of the HF discharge plasma parameters. Experiments were performed at 5 and 37 MHz, 3 and 10 GHz in quartz tubes with inside diameters 0.010, 0.013, 0.019, 0.080, and 0.090 m. Discharges were excited in dry air and nitrogen at 60-3000 Pa, ionization by a magnetron generator with maximum output power about 200 W at 2.4 GHz. Measurements show that in the pressure intervals studied, the concentration of primary electrons was  $8 \cdot 10^{12} - 2 \cdot 10^{13} \text{ cm}^{-3}$ . The presence of  $\text{H}_2\text{O}$  molecules in the discharge volume significantly changed the breakdown voltage, decreasing the volume occupied by the plasma by a factor of 12 to 15. Further increases in water concentration caused the output voltage of the HF generator to be insufficient to achieve breakdown in the tube. The form of the glow was thus shown to depend strongly on the pressure within the discharge tube and moisture content of the gas. Figures 1; references 10: 7 Russian, 3 Western. [6508-104]

#### INFLUENCE OF LASER RADIATION WAVELENGTH OF ENERGY YIELD OF SOFT X-RAYS FROM LASER PLASMA

Leningrad PISMA V ZHURNAL TEKHNIЧЕСKOY FIZIKI in Russian Vol 11, No 11, 12 Jul 85 (manuscript received 12 Feb 85) pp 667-669

ANANIN, O.B., BYKOVSKIY, Yu.A., KANTSYREV, V.L. and FRONDZEY, I.Ya.

[Abstract] A laser plasma formed by focusing of powerful laser radiation on a target in a vacuum is a source of soft x-radiation. A study is made of

the influence of laser radiation wavelength on energy yield. All experiments were performed with fixed radiation flux density of  $10^{10}$  W/cm<sup>2</sup>. The results agree with data produced earlier in the visible and infrared band at significantly higher power ( $10^{14}$  W/cm<sup>2</sup>). The results of this work cover a broader range of wavelength (0.337 micrometers to 10.6 micrometers), in which energy input is found to increase with decreasing wavelength.

References 6: 4 Russian, 2 Western.

[533-6508]

UDC 533.93

#### DIFFUSION DISCONTINUITIES IN INHOMOGENEOUS PLASMA WITH CURRENT

Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 146, No 2, Jun 85  
pp 237-265

DMITRIEV, A.P., ROZHANSKIY, V.A. and TSENDIN, L.D., Physical-Technical Institute imeni A.S. Ioffe, USSR Academy of Sciences, Leningrad Polytechnical Institute imeni N.I. Kalinin

[Abstract] This review of the literature investigates the evolution of the concentration profiles of a current-carrying inhomogeneous collisional plasma. Shortening of drift profiles and formation of abrupt concentration discontinuities are found to be a fairly general property of the slow processes (by comparison with sonic and Alfvén velocities) occurring in such plasmas. An effective approach is described that makes it possible to construct a physically clear picture of the phenomena by reducing the order of the original system of equations and reducing them to equations for simple nonlinear waves. Simple analytical solutions are found to be possible in a number of cases. The phenomena in question play an important role in the physics of plasmas in space and in the laboratory, as well as the physics and engineering of gas discharges, semiconductors, and electrolytes. Figures 19; references 55: 34 Russian, 21 Western.  
[521-6900]

UDC 537.525.5

#### NONLINEAR ULTRALOW FREQUENCY HYBRID WAVES IN A PLASMA

Gorky IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian Vol 28, No 6, Jun 85 (manuscript received 28 May 84) pp 792-794

CHMYREV, V.M., Institute of Terrestrial Magnetism, the Ionosphere and Radio Wave Propagation, USSR Academy of Sciences

[Abstract] Considering the specifics of polarization of hybrid waves but ignoring transverse displacement of electrons in the waves, a study is made

of the nonlinear movement of a plasma related to disturbances in field components  $E_x$ ,  $E_z$ , and  $B_y$ , longitudinal velocity of electrons  $v_z$ , and their density  $n$ . It is found that steady nonlinear hybrid waves exist in a plasma in the ultralow frequency band, propagating at an angle to the external magnetic field. The disturbance profile may be either a periodic wave or a combined compression or rarefaction wave. Figures 1; references 9: 3 Russian, 6 Western.  
[543-6508]

UDC 533.9.537.5

#### SPACE-TIME MODULATION OF ULTRARELATIVISTIC HIGH-CURRENT ELECTRON BEAM IN MAGNETIZED PLASMA WAVEGUIDE

Moscow FIZIKA PLAZMY in Russian Vol 11, No 7, Jul 85 (manuscript received 25 Jul 84) pp 797-801

KUZELEV, M.V., RUKHADZE, A.A., SANADZE, G.V. and FILIPPYCHEV, D.S., Moscow State University imeni N.V. Lomonosov

[Abstract] The problem of space-time modulation of an ultrarelativistic high-current electron beam in a magnetized plasma waveguide is solved on the basis of nonlinear equations derived in a previous study by the authors. A semi-infinite metal waveguide completely filled with a magnetized electron plasma penetrated by a thin monoenergetic electron beam is investigated. A system of equations is derived to describe the evolution of the wavefield. The beam is found to be entirely modulated by density, and relatively little by velocity, for beam currents of the order of the limiting vacuum; the modulation and beam velocity are both large for currents of the order of limiting Pierce current, and a significant number of electrons are found to be arrested and reflected back to the injector. The system of equations derived for the wavefield evolution can be used successfully in designing dense-beam travel-wave generators and amplifiers. Figures 4; references 13: 12 Russian, 1 Western.  
[532-6900]

UDC 533.951

#### TWO-POTENTIAL EDDIES IN MAGNETIZED PLASMA

Moscow FIZIKA PLAZMY in Russian Vol 11, No 7, Jul 85 (manuscript received 28 Feb 84) pp 836-869

MIKHAYLOVSKIY, A.B., LAKHIN, V.P. and MIKHAYLOVSKAYA

[Abstract] The initial equations for two-potential eddies associated with the nonelectrostatic branches of plasma oscillations derived by the authors

in a previous study are analyzed. Two types of two-potential eddies are investigated: purely electron eddies and electron-ion eddies, which correspond to the drift-Alfven branches of the oscillations of the plasma in a strong gravitational field. The existence of two-potential electron eddies requires that the plasma be strongly inhomogeneous. The occurrence of low-frequency long-wave two-potential eddies requires curvature of the lines of force of the magnetic field. Figures 1; references 8: 7 Russian, 1 Western.  
[532-6900]

UDC 533.951.8

STABILITY OF PLASMA STRUCTURES IN FIELD OF UNSTEADY LASER PULSE WITH FINITE LASER BEAM DIVERGENCE

Moscow FIZIKA PLAZMY in Russian Vol 11, No 7, Jul 85 (manuscript received 20 Sep 84 after revision) pp 865-869

NASTOYASHCHIY, A.F., Institute of Atomic Energy imeni I.V. Kurchatov

[Abstract] The stability of plasma structures irradiated by a high-power laser beam is investigated considering unsteadiness of the laser and pulse and the finite divergence of the laser beam, i.e., under near-experimental conditions. The influence of unsteadiness on plasma structure stability is investigated for anisobaric laser light absorption as an example. The finite divergence of the laser beam, or unsteadiness of the radiation, is shown to have a strong influence on the stability of plasma structures in the radiation field. Criteria are derived for finding the stability of layered structures. References: 6 Russian.  
[532-6900]

UDC 533.922

REFLECTION OF HIGH-INTENSITY RELATIVISTIC ELECTRON BEAMS BY SYNTHESIZED PLASMA LAYERS

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 55, No 7, Jul 85 (manuscript received 24 Feb 84, in final version 12 Feb 85)

AKOPOV, R.A., ANTABLYAN, O.G., DAVTYAN, S.V. and KHANIKYANTS, Ye.K., Scientific Research Institute of Physics of Condensed Media, Yerevan State University

[Abstract] Interaction of a high-intensity relativistic electron beam and a magnetodielectric surface is analyzed on the basis of experimental data, considering that precipitation of beam electrons on the surface ceases to be negligible close to the surface and adds to the Coulomb forces so that the

interaction ceases to be purely electrostatic. Reflection of the electron beam by the surface is a more adequate model and has been applied to reflection of synthesized plasma layers for analysis of that interaction. A material with the dielectric constant  $\epsilon = 2.6$  was placed in air under a pressure of 0.1 torr. Plasma layers were produced either by discharge sliding over the dielectric surface or by discharge between plane electrodes. High-voltage discharge pulses of amplitude up to 25 kV and with first half-period 120 ns long were generated by a TGI-1000/25 thyatron. The electron beam of 400 keV energy and 10 kA current was controlled by Faraday sleeves and a Rogowski loop at the accelerator exit. Electric transducer signals were recorded by two 6LOR-04 oscillographs operating in synchronism. The space-time patterns were determined initially with microwave probes at two wavelengths, 3 cm and 4 mm, and subsequently with Langmuir probes. The normal profiles of charge concentration and reflection force reveal that the former peaks at the surface and the latter peaks somewhat away from it, the patterns being quantitatively different in a sliding-discharge plasma and in an interelectrode-discharge plasma characterized by a higher recombination rate. Past that peak and thus beyond the "boundary" layer, a synthesized plasma appears to behave more like a metal reflector. Figures 4; references: 9 Russian.

[554-2415]

SUPERCONDUCTORS WITH HEAVY FERMIONS

Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 147, No 4, Dec 85, pp 767-779

ALEKSEEVSKIY, N.Ye. and KHOMSKIY, D.I., Institute of Physics Problems imeni S.I. Vavilov USSR Academy of Sciences; Physics Institute imeni P.N. Lebedev, USSR Academy of Sciences

[Abstract] Partially based on meetings of the USSR Academy of Sciences commission on superconductivity held in November 1984 and dedicated to a discussion of superconductors with heavy fermions, this article presents a general description of this interesting group of substances and is intended to draw the attention of a broader range of specialists. Systems with heavy fermions are rare earth metal and actinide compounds with unstable 4f- or 5f-shells. In these systems, the f level lies close to the Fermi level, producing an unstable valence. As a result, the states of the electrons at the Fermi level may take on an f nature and their properties may change significantly. There is actually a whole range of substances whose characteristics vary smoothly from normal to heavy fermion characteristics. The basic peculiarity of these systems is the strong interelectron correlation, small effective width of the zone and resultant similarity to a localized state, which may appear to some extent in other systems. A great deal of information has now been accumulated on the properties of systems with heavy fermions in both normal and superconducting phases. This class of substances may include the first example of nonstandard semiconductors, with anisotropic pairing and possibly even triplet states. Figures 4; references 58: 14 Russian, 44 Western.  
[6508-105]

UDC 538.4

MECHANISMS OF REDISTRIBUTION OF ALKALINE ADDITIVE IN MHD GENERATOR CHANNEL

Novosibirsk ZHURNAL PRIKLADNOY MEKHANIKI I TEKHNICHESKOY FIZIKI in Russian  
No 5, Sep-Oct 85 (manuscript received 19 Jun 84) pp 76-85

LAMDEN, D.I. and REZNIKOV, M.B., Moscow

[Abstract] The purpose of this work was to derive general expressions describing the redistribution of an additive under the influence of a combination of mechanisms and to analyze the contribution of each mechanism to the diffusion and mass transfer processes occurring with an easily ionized alkaline additive, such as potassium, in the channel of an MHD generator. References 15: 13 Russian, 2 Western.  
[6508/104]

UDC 621.375.8.038.823

ATMOSPHERIC-PRESSURE AND LOW-PRESSURE  $N_2$ -LASER AMPLIFIERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 12, No 4, Apr 85 (manuscript received 18 Jun 84) pp 820-825

SHANTA, I., KOZMA, L. and RACZ, B., Ja. Pannonius University, Pec;  
A. Iozef University, Seged

[Abstract] Three methods of electrical synchronization have been developed for excitation of nitrogen in a set of two-transverse-excitation  $N_2$ -lasers, an atmospheric-pressure one acting as oscillator and a low-pressure one acting as amplifier. A common feature of all three methods is application of a high voltage from a thyatron, but the necessary time delay can be effected, respectively, in three different locations at correspondingly three different voltage levels: 1) before the pulse amplifier - 5 V; 2) in the thyatron grid circuit - 300 V; 3) at the laser cell - 15 kV. In the first case, the two lasers operate completely independently and each in its optimum mode. In the second case, there is a separate thyatron for each laser and only the grid voltage of the one for the atmospheric-pressure laser is controlled, use of two independent thyatrons allowing both lasers to operate in their respective optimum modes. In the third case, there is only



one thyatron in common for both lasers and synchronization is effected by means of available inductive delay line on the high-voltage side of the atmospheric-pressure laser. The third method was found to be the best. A delay line for such a synchronization system was designed on the basis of applicable circuit and performance analysis. Experiments were performed with an atmospheric-pressure oscillator-laser (electrodes 200 mm long with a 4 mm radius of curvature spaced 3-4 mm apart) and a low-pressure amplifier-laser (electrodes 500 mm long with a 12.5 mm radius of curvature spaced 35 mm apart). The former had a plane-parallel capacitor attached to the cell and required a nitrogen supply of  $0.3 \text{ m}^3/\text{h}$ . The latter had 52 capacitors (1 nF - 12 kV) connected in parallel and required a nitrogen supply of  $5 \text{ m}^3/\text{h}$ . The two energy storing capacitors, 10  $\mu\text{F}$  and 100  $\mu\text{F}$ , respectively, were charged to 15 kV from a TGI 1-1000/25 thyatron at a repetition rate of 10 Hz. The pressure in the amplifier-laser cell was optimized at stable levels for maximum energy. Both the time delay of ignition in the low-pressure laser cell and the gain of this amplifier-laser were measured as functions of the gas pressure. Four optical systems were used, depending on the requirements, for widening the laser beam along its path from the oscillator exit to the amplifier entrance: 1) two spherical lenses for direct transmission, with unavoidable parasitic feedback; 2) two spherical mirrors for transmission with feedback, also with unavoidable astigmatism; 3) prism telescope, with unavoidable high losses at prism faces; 4) two lenses followed by a spectral selector. Cascading of two transverse-excitation  $\text{N}_2$ -lasers operating at different pressures in the active cell and with synchronization of discharges into an oscillator-amplifier system was found to make it feasible to generate short pulses of 1.5 ns duration with high power of 1.5 MW and small variance within 3%. Figures 6; references: 8 Western. [456-2415]

## SOLITON MECHANISM OF FRACTURE OF SOLIDS BY THERMAL FLUCTUATIONS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 27, No 7, Jul 85 (manuscript received 10 Nov 83, in final version 16 Jan 85) pp 2175-2179

LAGUNOV, V.A., Institute of Engineering Physics imeni A.F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] A theory of the soliton mechanism is being developed for explaining the fracture of solids by thermal fluctuations. It has so far been applied to one-dimensional anharmonic atom chains. A computer experiment has established the extent to which the soliton model is verifiable. The effect of thermal excitation and attendant fluctuations has been evaluated by numerical integration of the corresponding equation of motion for such an atom chain, with only interaction between adjacent atoms taken into account and that interaction described in terms of the Lennard-Jones potential. The object of the computer experiment was the kinetics and the dynamics of uniformly stretched atom chains momentarily heated by excitation into a state with a random normal distribution of atom velocities. The results reveal fracture of an anharmonic atom chain by thermal fluctuations under a mechanical load below the interatomic bond strength, thus indicating the dominant role of solitons and antisolitons in the process. Motion of an atom chain is possible without loss of stability in the case of thermodynamic equilibrium with zero average velocity of atoms, or with irreversible elongation of the chain already broken into two non-interacting segments. Characteristic of a heated atom chain is a nonuniform distribution of solitons and antisolitons in it, leading to local instability and thus ultimately fracture. The possibility of metastable highly elongated bonds in an atom chain under load and cyclic boundary conditions has already been demonstrated earlier, this computer experiment having further demonstrated a distinct inverse relation between the strain  $\varepsilon$  in the state of unstable equilibrium and the external loading force  $F$  ( $dF/d\varepsilon < 0$  at  $\varepsilon = \varepsilon_e$ ) in agreement with the relation based on the curve of potential as function of distance  $U(r)$ . The author thanks V.A. Stepanov for interest and helpful discussions. Figures 2; references 16: 11 Russian, 5 Western (1 in Russian translation).  
[579-2415]

## IGNITION AND COMBUSTION OF DISPERSE MIXTURES

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 5, May 85 (manuscript received 2 Nov 84) pp 69-72

DAVYDENKO, A.V., KUDINOV, V.M. and MAKARENKO, A.S., corresponding member, UkSSR Academy of Sciences, Institute of Electric Welding imeni Ye.O. Paton, UkSSR Academy of Sciences, Kiev

[Abstract] A theory of ignition and combustion is constructed for disperse mixtures and for homogeneous mixtures far from equilibrium which takes into account thermal relaxation. It is based on a known model of heat and mass transfer far from equilibrium, with thermal nonequilibrium introduced through relaxation of the stream or through relaxation of the internal energy. The resulting systems of two equations differ only in the first equation, namely, by the source term. After normalization to dimensionless form, they have been solved numerically with an Arrhenius source

$\frac{Q}{c}(\phi + \tau \frac{\partial \phi}{\partial t} - \tau \frac{\partial^2 \phi}{\partial x^2})$  in the first case and a source  $\frac{Q}{c}(\phi + \tau \frac{\partial \phi}{\partial t})$  in the

second case ( $\tau_1, \tau_2$  - relaxation times,  $c$  - specific heat,  $\phi$  - chemical potential). Peaking of the temperature profile during ignition by a hot surface and widening of the wavefront of steady flame propagation are found to occur in both cases later than according to the parabolic model, with the steady-state profile reached at higher temperatures. The new theory embraces the classical one for small deviations from equilibrium, as the limiting case. Figures 3; references 10: 9 Russian, 1 Western (in Russian translation).

[494-2415]

## MICROWAVE BEAM INSTABILITY IN PROTON SYNCHROTRONS

Moscow ATOMNAYA ENERGIYA in Russian Vol 59, No 1, Jul 85 (manuscript received 9 Feb 84) pp 42-48

BALBEKOV, V.I. and IVANOV, S.V.

[Abstract] Longitudinal instability of bunched proton beams has been described, according to A.N. Lebedev (1968), by an infinite system of differential equations for the beam current harmonics or an equivalent integral equation for the charge density. Solution of the problem was attempted, with the simplifying assumptions that all beams are identical and uniformly spaced, that the impedance of the chamber is determined by the element with a narrow resonance peak, and that instability is manifested in the form of multipole oscillations of particle beams without coupling between dipole, quadrupole, and higher-order multipole oscillations. While the first two assumptions appear to be physically plausible, the third one is not so obvious. It is interpreted either in terms of evolution from an initial necessarily multipole oscillation to an eventual coupling of different multipoles or in terms of an azimuthally uniform beam in a high-frequency impedance chamber and a correspondingly microwave instability. Any instability mode is determined by the ratio of beam length to resonator wavelength and the synchrotron frequency deviation. When both parameters are small, then instability will occur in the multipole mode. When their product is large, then instability will occur in the microwave mode. The dispersion equation for the frequency of synchrotron oscillations in a beam yields for these two cases instability near the threshold and thus also the possibility of microwave instability near the threshold. The mechanism of this instability mode is physically interpretable in the phase plane of synchrotron oscillations and in terms of systemal particle-beam interaction occurring only along phase trajectories which satisfy the resonance condition. For the intermediate range between multipole and microwave instabilities, a stability criterion is defined in the form of a threshold circle slit radially along the positive imaginary admittance axis. This criterion is further explicated for the most practical case of a weak nonlinearity with the synchrotron frequency deviation not exceeding 0.3 and a large frequency increment. The accuracy of correspondingly assuming a "triangular" energy distribution of synchrotron oscillations is estimated and compared with that of a "parabolic" distribution. Figures 3; references 8: 4 Russian, 4 Western (1 in Russian translation).  
[546-2415]

UDC 62-50

THE ROLE OF INFORMATION IN A PURSUIT PROBLEM

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR SERIYA A. FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 11, Nov 85 (manuscript received 4 Jan 85) pp 70-73

CHIKRIN, A.A. and PITTSYK, M.V., Institute of Cybernetics, Ukrainian Academy of Sciences, Kiev

[Abstract] Continuing previous studies, this article establishes sufficient conditions for coincidence and difference of pursuit time based on the first direct method of Pontryagin with the time of one effective pursuit method presented in the previous articles in this series, and thus clarifies the influence of information available to the pursuer concerning the prehistory of control of the pursued object on game completion time within the framework of these methods. References: 6 Russian.  
[6508-90]

UDC 519.9

DIFFERENTIAL PURSUIT GAMES WITH INTEGRAL LIMITATIONS

Dushanbe DOKLADY AKADEMII NAUK TADZHIKSKOY SSR in Russian No 8, Aug 85 (manuscript received 8 Feb 85) pp 431-433

MUKHSINOV, Ye.M., Leningrad State Pedagogy Institute imeni S.M. Kirov

[Abstract] This article studies a linear differential pursuit game in a Hilbert space for the case when integral limitations are placed on the actions of the players. Sufficient conditions are obtained allowing a set of initial points to be found from which the pursuit can be completed. References: 6 Russian.  
[6508-92]

SETS OF PROGRAMS FOR NUMERICAL SOLUTION OF QUANTUM PROBLEM OF SCATTERING IN  
THREE-PARTICLE SYSTEM

Moscow AKADEMIYA NAUK SSSR, FIZICHESKIY INSTITUT IMENI P.N. LEBEDEVA  
in Russian Preprint No 2, 1984

POZDNEYEV, S.A.

[Abstract] The system of Fadeyev integral and differential equations in the wave function for three bodies is applied to a system of three charged elementary particles. In the special case of only two charged particles among them, the problem is reduced to elastic and Coulomb scattering of the neutron and the proton, respectively, by the deuteron in a bispherical basis with asymptotic boundary conditions. By extraction of the angular variables, in the approximation of separable variables, the set of three-dimensional integral equations in this system is reduced to a one-dimensional one. The latter is solved by integration along the real axis according to a modification of the standard numerical method, which involves reduction to algebraic equations with the use of Lagrange interpolation polynomials and quadratures. The computer program for solving these equations is written in FORTRAN and includes the subroutines GEOMET, GRID-MOON, MTRX (BLOCK 1...BLOCK 9 followed by CARRY with TAUP, NOPOLE, QEQQ, LOGG, STRAIGHT), FINAL (SOLVE - BREAK). The set of differential equations in this system is solved by the method of grids and splines after finite-difference approximation in polar coordinates, with use of the Gauss algorithm for matrix inversion and of asymptotic formulas after elimination of unknowns. The computer program for solving these equations is written in FORTRAN and includes the subroutines CASCHA, POT, COUL, POLDS, PLEG, DEUT, ELM, HYP, WLT, HYPER, TRIAN, RESOL, ELAB. Both sets of programs are universal, neither logic nor software being tied to any particular hardware, and can be executed efficiently and flexibly on BESM-6, SAYBER-172, SDS-6500, YeS-1045, or other computers. Figures 2; tables 1; references 57: 37 Russian, 20 Western (1 in Russian translation).  
[437-2415]

## NEW PHOTONUCLEAR DATA PROCESSING ALGORITHMS

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA. SERIYA 3 FIZIKA. ASTRONOMIYA in Russian Vol 26, No 6, Nov-Dec 85 (manuscript received 21 Nov 84) pp 3-7

BODYSHEV, V.N. and YUDIN, D.V., Department of Mathematics

[Abstract] A study is made of algorithms allowing solution of the problem of reducing the required dimensionalities in the processing of results of photonuclear experiment measurements much more rapidly and accurately than can be done by traditional methods. The results of reduction of the cross-section of a photonuclear reaction of  $^{12}\text{C}(\gamma, n)$  obtained with the algorithm suggested are presented. Figures 3; references: 6 Russian. [6508-97]

## A NEW APPROACH TO CONSTRUCTING NUMERICAL ALGORITHMS FOR SOLVING CAUCHY PROBLEMS FOR HIGHER-ORDER DIFFERENTIAL EQUATIONS

Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 29, No 5, 1985 (manuscript received 21 Feb 84) pp 389-392

VORONTSOV, V.M., Grodno State University

[Abstract] A theoretical proof is given for linear multistep methods that can be used to solve the Cauchy problem for higher-order differential equations. The coefficients of the analytical formulas are found by solving a special minimization problem for a nonlinear functional (the sum of the absolute value of the coefficients) with linear constraints. Five theorems are stated and proved. The effectiveness of the computational rules derived are tested experimentally and shown to be superior to the existing Adams and Runge-Kutt algorithms. References: 5 Russian. [442-6900]

## SOLVABILITY OF OBSERVATION PROBLEM WITH SENSITIVITY ALGORITHM

Kiev MATEMATICHESKAYA FIZIKA I Nelineynaya Mekhanika in Russian No 3 (37), 1985 (manuscript received 30 Dec 81) pp 20-25

KONOSEVICH, B.I., Institute of Applied Mathematics and Mechanics, UkSSR Academy of Sciences, Donetsk

[Abstract] The problem of observing a dynamic system by measuring its discrete output signal is formulated for a deterministic dynamic system

describable by the equations  $dz(t)/dt = f(t, z(t))$ ,  $\rho_i(t_{ij}, z(t_{ij})) = g_{ij}$  where  $i = 1, \dots, m$ ,  $j = 1, \dots, n_i$ ,  $f: \Omega \rightarrow R^n$  and  $\rho_i: \Omega \rightarrow R$  are functions defined in some region  $\Omega \subset R \times R^n$ , and  $t_{ij}, g_{ij}$  are numbers given for each of functions  $\rho_i$ ,  $n_1 + n_2 + \dots + n_m = n$ . An existence and uniqueness theorem for the solution to this problem is proved, being preceded by one lemma and followed by two lemmas pertaining to functions  $f$  and  $\rho_i$ . This theorem also establishes the conditions under which the solution can be obtained with the well-known sensitivity algorithm. References 5: 4 Russian, 1 Western (in Russian translation).  
[589-2415]

UDC 537.534

# SIMULATION OF INTERACTION BETWEEN HIGH-CURRENT RELATIVISTIC ELECTRON BEAM AND MATTER

Moscow FIZIKA PLAZMY in Russian, Vol 11, No 7, Jul 85 (manuscript received 24 Oct 84) pp 787-796

GOREV, V.V., GRIGORYEV, S.F., KOLDOVA, A.V., POVESHCHENKO, Yu.A., POPOV, Yu.P., POPOV, S.V., RUDAKOV, L.I. and SAMARSKIY, A.A., Institute of Atomic Energy imeni I.V. Kurchatov

[Abstract] A closed mathematical model is constructed for the interaction between a high-current relativistic electron beam and matter. A series of computer calculations are described, and the results are compared with experimental findings. The comparison shows that the proposed theoretical representations pertaining to a three-component plasma system (an electron-ion plasma and the gas of "hot" relativistic electrons) in fact reflect the basic characteristics of the actual process. The mathematical models and computer analysis methods developed make it possible to analyze the mechanism underlying the anomalous energy contribution of relativistic electron beams to matter. Figures 8; references 19: 15 Russian, 4 Western.  
[532-6900]



## CONVERGENCE OF FUNCTIONALS WITH RESPECT TO SUPERCRITICAL MARKOV PROCESSES WITH BRANCHING

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 283, No 4, Aug 85  
(manuscript received 25 Oct 83) pp 791-794

BELYAYEV, M.Yu., Moscow State University imeni M.V. Lomonosov

[Abstract] Supercritical Markov processes with branching property are considered, and linear functionals of the "number of particles" kind for such processes are tested for convergence. A theorem is proved which holds true under the condition which models the finite-dimensional Frobenius theorem in the ring of bounded measurable complex-value functions in the complete separable measurable space. Upon stipulation of three other conditions, a second theorem with two corollaries and a third theorem are proved. For demonstration, a process is considered which involves two kinds of particles and fission of each particle within a discrete time period, producing a random number of mutually independent daughter particles characterized by a generating function  $F(z) = 1 - [\frac{\lambda}{\alpha} (1 - e^{\alpha z}) + e^{-\alpha z} (1 - z)^{-\alpha}]^{-1/\alpha}$   $0 < \alpha < 1$ ,  $\lambda, \alpha > 0$  and invariant with respect to the kind of parent particles. Other examples are nonfactorable Halton-Watson process with several kinds of particles and with second moments satisfying all three conditions and joint distribution of several functionals of the "number of particles" kind. Article was presented by Academician A.N. Kolmogorov on 12 October 1983. References 4: 1 Russian, 1 Czechoslovak, 2 Western.  
[552-2415]

## METHOD FOR RANDOMIZING INTEGRAL OPERATOR TO SOLVE EQUATIONS OF SECOND KIND

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 283, No 4, Aug 85  
(manuscript received 11 Jun 84) pp 797-800

BULAVSKIY, Yu.V., Computer Center, Siberian Department, USSR Academy of Sciences, Novosibirsk

[Abstract] Solution of an integral equation of the second kind  $u(x) = Ku(x) + f(x)$  representing  $u(x) = \int_X k(x, x') u(x') dx' + f(x)$  by its randomization is proposed, with the approximate solution sought as linear combination of solutions to an array of low-order algebraic systems, rather than by conventional iteration and evaluation of the operator  $K$ . The gist of this method is demonstrated on a system of linear algebraic equations  $Au = f$  with a quadratic nonsingular matrix  $A$  of order  $N$ . It is then extended to an equation  $u(x) = Ku(x) + f(x)$  where  $k(x, x')$  and  $f(x)$  are bounded in a

region  $X \subset R^k$  and unity is not an eigenvalue of the operator  $K$  so that equation with any expression on the right-hand side is uniquely solvable. The method is validated by a lemma applicable to  $n$  points of a Poisson distribution and existence of the solution  $u(x) = \frac{M \det A_x(x_1, x_2, \dots, x_n)}{M \det A(x_1, x_2, \dots, x_n)} \quad x \in X$ .

Calculations on a BESM-6 high-speed computer have yielded, within 51 s of machine time, a solution with a 1% dispersion for  $k = 1$  and a solution with a 2% dispersion for  $k = 2$ . Article was presented by Academician M.M. Lavrentyev on 29 May 1984. References: 5 Russian. [552-2415]

UDC 533.6.011

# SOLUTION OF BOLTZMANN EQUATION FOR DISCRETE VELOCITIES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 283, No 4, Aug 85  
(manuscript received 8 May 84) pp 831-834

ARISTOV, V.V., Computer Center, USSR Academy of Sciences, Moscow

[Abstract] Solution of the nonlinear Boltzmann equation for the kinetic theory of gases by the method of discrete velocities is considered, with exact evaluation of the quintuple integrals in the velocity space replacing their numerical evaluations by the Monte Carlo method. The equation is put in the form  $\frac{\partial f}{\partial t} + \frac{\partial f}{\partial x} = I(\xi)$ ,  $I(\xi) \equiv \int \xi(f'f_1 - ff_1)g\sigma(g,s)ds$  ( $g = |\xi - \xi_1|$  - modulus of relative velocity between colliding particles,  $f(t,x,\xi)$  - distribution function,  $\sigma(g,s)$  cross-section for collisions,  $s = \{\sqrt{1-p^2} \cos \xi, \sqrt{1-p^2} \sin \xi, p\}$ ,  $ds = dp d\xi$ ,  $p = \cos \theta$ ,  $\theta$  - scattering angle). It is solved for the case of elastic spheres:  $\sigma = \text{const}$  and  $I = -\nu f + N$ , ( $\nu f$  - integral of forward collisions,  $N$  - integral of backward collisions). The collision operator is approximated in two steps, triple numerical integration with respect to velocities by the method of rectangles at the center being followed by integration of each term in the preceding sum with respect to the collision parameters  $p, \xi$ . The advantage of this method is that it does not require special approximation of angles. Corrections can be made so as to satisfy the laws of conservation. The method was successfully tried on the problem of spatially isotropic velocities, requiring only about 30 s of machine time on a BESM-6 high-speed computer and thus about one-tenth of the machine time required by evaluation of all coefficients  $b_{lij}$  in the  $\frac{df_1}{dt} = \sum_{i,j} b_{lij} f_i f_j$  ( $i = 1, \dots, L$ ) formulation on the Boltzmann equation.

Article was presented by Academician A.A. Dorodnitsyn on 27 April 1984. Figures 2; references: 5 Russian. [552-2415]

## PROJECTION ALGORITHMS FOR IDENTIFICATION OF LINEAR OBJECTS

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 7, Jul 85 (manuscript received 11 May 84) pp 62-64

ISHCHENKO, L.A., LIBEROL, B.D. and RUDENKO, O.G., Kharkov Institute of Radioelectronics

[Abstract] Identification of linear objects by their projection onto orthogonal subspaces is considered, taking into account the properties of the projection operator, as well as the statistical properties of the vectors. The accuracy of identification is characterized by a fitting analog of the Liapunov function. Three estimation theorems are proved with the aid of three lemmas, one for a unity numerical coefficient, one for an arbitrary sequence of the numerical coefficient without interference, and one for an arbitrary sequence of the numerical coefficient with interference. The convergence of the estimation algorithms follows from respective corollaries. The parameters of these algorithms, such as their memory, can be selected for maximum convergence rate. Article was presented by Academician (UkSSR Academy of Sciences) V.I. Skurikhin. References 5: 3 Russian, 2 Western (both in Russian translation). [540-2415]

UDC 519.242

PROBLEMS OF OPTIMAL MEASUREMENT OF A GAUSSIAN SIGNAL

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA. SERIYA 3 FIZIKA. ASTRONOMIYA  
in Russian Vol 26, No 6, Nov-Dec 85 (manuscript received 3 Jan 85) pp 17-21

GOLUBTSOV, P.V., PYTEV, Yu.P. and CHULICHKOV, A.I., Department of Mathematics

[Abstract] A study is made of problems related to refining the values of a finite set of parameters of an object based on their indirect measurement if the a priori distributions of these parameters and of measurement errors are known. In particular, the a posteriori distribution of measured parameters of the object is found and problems of planning measurements for the best refinement are solved. References: 3 Russian.  
[6508-97]

UDC 621.396.677.7

RADIATION OF MAGNETIC WAVES FROM TWO AND THREE FLAT WAVEGUIDES

Gorky IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: RADIOFIZIKA in Russian  
Vol 28, No 6, Jun 85 (manuscript received 28 Feb 84; after combination,  
30 May 84) pp 763-776

ZHURAV, S.M., Moscow Institute of Control

[Abstract] Radiation from several flat waveguides is of practical interest in studying the characteristics of low-directivity radiators and simple models of finite phased antenna arrays. This work studies the radiation of magnetic waves from two waveguides of different height and from three waveguides of equal height, the structures consisting of three and four infinitely thin, ideally conducting half planes. The problem is solved by a method based on the method of Wiener and Hopf. Numerical results are included. Figures 11; references: 2 Russian.  
[543-6508]

UDC 519.248

OPTIMIZATION OF MOMENTS OF SYSTEMS MONITORING AND REPLACEMENT

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNICHESKIYE NAUKI in Russian No 7, Jul 85 (manuscript received 4 Jun 84) pp 64-67

NAKONECHNYI, A.N., Institute of Cybernetics imeni V.M. Glushkov, UkSSR Academy of Sciences

[Abstract] A class of fractional-linear functionals defined on a strictly Markovian process is considered, and the sufficient conditions are established for existence of a unique solution to the problem of their minimization. The accuracy of that solution is estimated by projection of stochastic gradients. The applicability of this method is based on a theorem, which is proved here with the aid of a lemma and which also allows using a quasi-gradient. The procedure is demonstrated on optimization of the operating time of a system with protection till failure occurs and replacement becomes necessary, taking into account the cost factor. Calculations are expediently done by the Fibonacci method. Article was presented by Academician (UkSSR Academy of Sciences) I.N. Kovalenko. References: 8 Russian. [540-2415]

UDC 518.9

MULTISTEP SYSTEM FOR GENERALIZED MATHEMATICAL PROGRAMMING AND SELECTION FUNCTION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 282, No 5, Jun 85 (manuscript received 2 Nov 84) pp 1066-1069

YUDIN, D.B. and SHOLOMOV, L.A., All-Union Scientific Research Institute of Systems Research, Moscow

[Abstract] Previous works have formulated the problem of generalized mathematical programming, describing a certain class of mechanisms for optimal selection of objects of arbitrary nature based on a generally arbitrary set of binary relationships. This article continues the studies

and extends them into the area of multistep selection systems. The selection function is a multivalued mapping. The purpose of the article is to establish correspondence between selection functions and their possibility of implementation by mechanisms. References 8: 7 Russian, 1 Western. [526-6508]

UDC 519.95

# MODELING CERTAIN CLASSES OF GAUSSIAN RANDOM PROCESSES

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA A: FIZIKO-MATEMATICHESKIYE I TEKHNIЧЕСKIYE NAUKI in Russian No 6, Jun 85 (manuscript received 20 Apr 84) pp 71-74

ZELEPUGINA, I.N., Kiev University

[Abstract] a model  $\hat{\xi}(t) = \sum_{k=1}^n \xi_k S_k(t)$  of a Gaussian random process  $\xi(t)$ ,  $t \in [a, b]$  in uniform metrics is considered, in the class of processes with a sequence of mutually independent  $\xi_k$  and a trigonometric completely orthogonal system of functions on the  $[a, b]$  interval. These processes include stationary periodic ones and processes reducible to stationary periodic ones when, for instance, their correlation functions are expandable into Fourier series with non-negative coefficients. Each of these two kinds of processes is treated separately, convergence of their computer simulation being validated by an enabling minimization theorem which is proved here. Article was presented by Academician V.S. Mikhalevich. References 4: 3 Russian, 1 Western (in Russian translation). [557-2415]

## DIFFERENTIAL EQUATIONS

UDC 517.9

### RANDOM VIBRATIONS IN CERTAIN NONLINEAR VISCOELASTIC SYSTEMS

Kiev UKRAINSKIY MATEMATICHESKIY ZHURNAL in Russian Vol 37, No 4, Jul-Aug 85  
(manuscript received 20 Jan 85) pp 468-472

MITROPOLSKIY, Yu.A. and NGUYEN DON AN, Institute of Mathematics, UkSSR  
Academy of Sciences, Kiev

[Abstract] Random vibrations in nonlinear viscoelastic systems describable by the general stochastic integro-differential equation  $\ddot{x} + \omega^2 x = \xi F(x, \dot{x}, t) + \xi \int_0^t [K(t-s)x(s) + R(t-s)\dot{x}(s)]ds + \sqrt{\epsilon} h(x, \dot{x}) q(t)$  are analyzed, assuming that the two relaxation kernels  $K(0)$  and  $R(0)$  associated with displacement and velocity, respectively, converge fast to zero as  $s \rightarrow \infty$ . The integro-differential equation is reduced to an ordinary differential one, and the correlation function of the vibration process is calculated for the simple system  $\ddot{x} + \omega^2 x = \xi \int_0^t K(t-s)x(s)ds + q(t)$  under centered stationary random action and for two more intricate systems under "white noise" action and periodic action, respectively. References: 9 Russian.  
[558-2415]

UDC 517.926

### WEAKLY REGULAR LINEAR SYSTEMS OF DIFFERENTIAL EQUATIONS

Kiev UKRAINSKIY MATEMATICHESKIY ZHURNAL in Russian Vol 37, No 4, Jul-Aug 85  
(manuscript received 23 Oct 84) pp 501-506

KULIK, V.L., Institute of Mathematics, UkSSR Academy of Sciences, Kiev

[Abstract] Linear systems of differential equations describing transients in dynamic systems under perturbation are analyzed, such a system  $\dot{x} = A(t)x$  with  $x \in \mathbb{R}^n$  and  $\dot{x} = dx/dt$  being weakly regular along the entire  $\mathbb{R}$ -axis from  $-\infty$  to  $+\infty$  when the nonhomogeneous system  $\dot{x} = A(t)x + f(t)$  has at least one solution bounded on  $\mathbb{R}$  for every fixed vector-function  $f(t) \in C^0(\mathbb{R})$  and being regular when it has only one such solution. An

existence theorem for weakly regular systems is proved, and on its basis the necessary condition is established for a solution bounded on  $R$ , this condition shown to be also sufficient. Another theorem is proved and followed by a corollary pertaining to the existence of  $n \times n$ -dimensional symmetrical continuously differentiable matrix functions for solving the system of equations where the  $n \times n$ -dimensional matrix function  $A(t)$  is continuous and bounded on  $R$ . References: 7 Russian.  
[558-2415]

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